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THE UNIVERSITY OF ALBERTA

SOIL SURVEY INTERPRETATIONS FOR RECREATION SITE PLANNING  
IN TWO ALBERTA PROVINCIAL PARKS

by



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A THESIS

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The undersigned certify that they have read, and recommend to the Faculty of Graduate Studies for acceptance, a thesis entitled "Soil survey interpretations for recreation site planning in two Alberta provincial parks" submitted by Larry K. Brocke, B.Sc., in partial fulfilment of the requirements for the degree of Master of Science.



## ABSTRACT

The recent increased demand and competition for land has resulted in an increased demand for careful land use planning. The planning of outdoor recreation areas is no exception. In studies conducted elsewhere soil survey information has been found essential to planning outdoor recreation areas.

This project was undertaken to provide some basic soil survey information for two Alberta provincial parks and to determine the applicability of the information in establishing suitability soil groupings for various outdoor recreation activities. The recreation activities considered are camping areas, playground areas, picnic areas, hiking trails, permanent buildings, roads, and sewage disposal.

Detailed soil surveys were conducted and dominant mapping units were characterized by chemical and physical analyses. Soils of the Luvisolic order in the Canadian System of Soil Classification were found to be dominant in both parks. Miquelon Lake Provincial Park is characterized by hummocky terrain on which the soils occur in a toposequence. Sir Winston Churchill Provincial Park is characterized by very complex soil patterns on which topography appears to have no influence.

Interpretation of the soil survey information and



analytical results indicated that most soils in the two parks have moderate to severe soil limitations for recreation use suggesting careful planning, design, and management are required for the development of these two parks. However, it is not suggested that development be avoided but rather that soil survey information is an essential aid to recreation land use planning.



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## I. INTRODUCTION

The increased demand and competition for land has necessitated the development of more careful approaches in all facets of land use planning. In the past, the supply of land has far exceeded the demand resulting in only rare occasions of careful land use planning. In the future, however, land will become a more desired resource and, since land is a renewable resource only over a long period of time, careful land use planning will be a necessity. The planning of outdoor recreation areas is no exception.

The demand for outdoor recreation areas has been steadily increasing as a result of steadily increasing incomes and leisure time and will continue to do so as long as industrialization continues to increase. Consider the statement made by David Sarnoff, Chairman of the Radio Corporation of America, in the January 1955 issue of Fortune:

"Leisure, of course, will be greatly extended. A much shorter week will no doubt prevail in 1980, and another ten or fifteen years will have been added to the average life span. . . .

Not labor but leisure will be the great problem in the decades ahead. . . ."

Thus, the increased demand for outdoor recreation areas coupled with the increased demand for land, in general, has further necessitated the need for carefully planned and administered outdoor recreation areas.



In studies conducted elsewhere it has been found that soil surveys provide fundamental information essential to planning outdoor recreation areas. Proper planning of selected recreation areas aided by the use of soil survey information would, by preventing overdevelopment, limit each area to its capability and thus, prevent the deterioration and destruction of the land resource base. A lack of suitable soil survey information presently exists in Alberta with respect to outdoor recreation areas.

The purpose of this project is to provide some basic soil survey information for two Alberta Provincial Parks and to determine the applicability of the information in establishing suitability soil groupings for various outdoor recreation activities. To achieve this purpose I believe the following objectives should be pursued:

- (1) to conduct a high intensity soil survey of the selected provincial parks.
- (2) to conduct chemical and physical studies in the field and laboratory in order to characterize the mapping units and establish their significance to planning outdoor recreation areas.
- (3) to evaluate mapping units in terms of suitability for various outdoor recreation activities.



## II. LITERATURE REVIEW

### Present Approaches to Recreation Land Use Planning

In comparison to other fields, recreation has been the subject of very little research. The Outdoor Recreation Resource Review Commission of America (1962) stated that "no other activity involving as many people and as basic a part of our life has received less attention from qualified investigators and scientists."

Although there is a general lack of information based on sound systematic studies, several approaches to the classification of land for recreation inventories are in use at the present time. These can be divided into three groups according to their respective definitive criteria as follows:

- (1) Techniques based on physiographic criteria (Hills, 1961 and de Vries, 1965).
- (2) Techniques based on a combination of physiographic and perceptual criteria (Lewis, 1961; A.R.D.A., 1965; and Taylor, 1965).
- (3) Techniques based on economic criteria which are generally invalid for classifying recreation potentials.

Verburg (1966) analyzed many of the techniques in use and found that all were subject to various limitations and that, at best, any one of the classification techniques could be used only



for a very broad regional classification of land for recreation purposes. Verburg thus attempted to develop a technique from the existing techniques which would be more specific in defining class limits.

Although Verburg (1966) designed a more quantitative system of classification for recreation lands it is at best useful only for inventory purposes. It is a more accurate system than the previous systems and should be most useful for selecting recreation areas for future development. However, I feel that the mechanics of the system render it unsuitable for site planning and suggest that suitable interpretations of detailed soil survey information would better serve the purpose of site planning.

#### Some Interpretive Soil Classification Systems in Use

Interpretive soil classification systems may take on any one of many forms depending on the purpose or objective for which they are designed. The purpose of each interpretive system regulates the soil properties used to construct the interpretive groupings. For example, soil properties important to agricultural production do not necessarily carry the same importance to engineering or recreational "production". Therefore, at the outset it is necessary to state the soil properties upon which the interpretive groupings are to be based. Without this condition any interpretive soil classification system is meaningless and will serve no useful purpose.



At the present time interpretive soil classification systems have been developed for:

- (1) Agriculture (Barnes and Harper, 1949; Krantz, 1958; Klingebiel and Montgomery, 1961; Retzer and Doran, 1964; A.R.D.A., 1965).
- (2) Engineering purposes such as the use of soil as a construction material (Stokstad and Humbert, 1949; Stokstad, 1958; Davis, 1962; Orvedal, 1963; Olson, 1964; Huddleston, 1965; Terzaghi and Peck, 1967).
- (3) Urban Development which includes engineering purposes with considerations such as fertility and physiography (Robinson et al., 1955; Hutchinson and Arno, 1965; Witwer, 1965; Yanggen et al., 1966).
- (4) Many others such as Zoning Ordinances (Beatty and Yanggen, 1966) and Tax Equalization (Kinney, 1966).

Interpretive Soil Classification for Agriculture. There are a number of interpretive soil classifications for agricultural purposes. The basic soil survey map provides the information required for making the interpretive groupings. The soil survey map is based on the taxonomic soil classification and shows the kinds of soils present, their distribution, and important characteristics. From this basic information different soils may be grouped according to their suitability for various agricultural uses.

One interpretive soil classification for agriculture is the capability classification used by the U.S.D.A. Soil Conservation



Service (Klingebiel and Montgomery, 1961). In this system the soils considered to be arable are grouped according to their potentialities and limitations for sustained production of the common cultivated crops that do not require any specialized management practises. The soils considered to be non-arable are grouped according to their potentialities and limitations for the production of perennial vegetation and according to their risks of soil damage if mismanaged.

The capability classification for agriculture used in Canada (A.R.D.A., 1965) is similar to the U.S.D.A. system. It is different in that it provides only two major categories of soil groupings whereas the U.S.D.A. system provides three categories. The U.S.D.A. categories are the capability class, the capability subclass, and the capability unit in order of decreasing generalization. The A.R.D.A. system does not provide the capability unit category limiting its use to inventory purposes whereas the U.S.D.A. system can be used for individual farm planning.

However, the basic design of both the U.S.D.A. and A.R.D.A. systems is similar and each system has a number of assumptions in assigning the soils to the respective categories. Any interpretive soil classification system requires a set of basic assumptions to enable consistent groupings over a large area such as Western Canada and to ensure proper use of the categories. Using these basic assumptions, an interpretive soil classification for agriculture has been developed from the basic taxonomic soil classification. The use of the capability classification for agriculture will ensure



maximum production without jeopardizing the conservation of the natural resource base.

Interpretive Soil Classification for Engineering Purposes. The function of soil surveys in making interpretations for engineering purposes is paramount. As Aandahl (1958) stated, "the function of soil survey interpretation for engineering use is one of providing accurate, complete information on soil character and behavior as an adequate and reliable basis of design and construction and the alternatives possible in using them as construction materials or for foundations". Stokstad and Humbert (1949) also stated that engineers must have information regarding the environment of the construction site which, since soil types are the product of environmental factors acting on the parent material, can be provided by the soil survey.

Since soil is the oldest and most used of construction materials, information regarding the behavior of soils is of vital importance to the engineer. As a consequence of this need for soils information the engineers have developed several classification systems for use in conjunction with soil survey maps. It is in this relationship that Soil Science can best contribute to the Science of Engineering: first, by providing good techniques for mapping and describing soil profiles in the field and second, by providing a well developed descriptive legend of soil types for the soil map (Stokstad, 1958).



Of the several engineering classification systems that have been developed only two are in common use: the Unified system and the American Association of State Highway Officials system. The Unified system finds its greatest value in predicting the behavior of soils for foundations of small buildings and embankments. The A.A.S.H.O. system finds its greatest value in designing highways, airports, and the foundations of large extensive structures. Both systems have been used successfully with the Unified system receiving the most widespread use at the present time.\*

Thus with identification by the aid of soil survey reports, the engineering classification and with established guides of interpretation many engineering properties, characteristics, and applications may be predicted. For example, in 1961 the U.S.D.A. Soil Conservation Service established a guide for estimating some of the engineering properties which pertain to conservation and agricultural engineering. The U.S. Army Corps of Engineers, in 1957, established an interpretive guide for estimating soil engineering properties after classification according to the Unified system. The Federal Housing Administration, in 1961, also established an interpretive guide to be used with the Unified system. All of the above mentioned interpretations of soil information for engineering purposes employ one of the engineering classification systems in conjunction with the basic taxonomic

\* Personal communication with Dr. S. Thompson, Dept. of Civ. Eng., U. of A.



soil survey.

More recently, however, attempts have been made to relate the basic taxonomic soil survey directly to various engineering usages of soil and perhaps this approach is more relevant to the present project.

Direct Engineering Interpretations from the Basic Taxonomic Soil

Survey. The use of soils for sewage disposal and the prediction of the suitability of a given soil for such use is one attempt at direct engineering interpretations. Clayton et al. (1959) found that after percolation potential was determined for soils representative of a given soil series, the information could be projected to other sites with similar soils by using detailed soil survey maps as a guide. When trunk sewage disposal lines were not available, the size of the building lot for an individual home site and the quality of the house built was regulated by soil type. Huddleston (1965), in Broome County New York, also noted that sewage disposal problems were directly related to soil type, and planning individual sewage disposal units could be based on soil type.

Numerous attempts have been made to use soil surveys in urban planning. Hill and Shearin (1960) have shown that interpretations of engineering properties from basic soil surveys are useful in planning and zoning and in anticipating remedial measures. Bartelli (1961) discussed the use of soil surveys in the planning and development of urban fringe areas and stated that



engineering use and interest in these areas centres around the use of the soils for roadways, foundations, and sewage disposal fields.

Quay (1966) described a procedure useful in applying the basic soil survey map and its various interpretations to subdivision design. Soil interpretations pertinent to the problem in the specific area were selected. These included percolation rate, flood potential, water table, bearing strength, corrosion potential, shrink-swell potential, erosion potential, frost action, and agricultural capabilities, all of which were inferred from data in the basic soil survey report and map. The results showed that a successful low-density residential subdivision design based on soils information could eliminate some of the problems of subdivision design that occur with the use of an arbitrary gridiron system of design.

Olson and Marshall (1968) described how high intensity soil surveys could be used for large development projects. Their study illustrated how interpretations of high intensity soil surveys were used to select building sites for a dormitory complex and a conference centre on the campus at Cornell University in New York State. On the basis of the soil map, along with other environmental considerations, the dormitory complex was located in the section of the development area where the soils were relatively well drained, had good foundation support characteristics, and fair landscaping possibilities compared to other sections of the development area. The conference centre was located in the section



where the physiography of the soils offered the greatest aesthetic value as well as sound construction values. Furthermore, and most important, they did not hesitate to reveal the limitations of their study. They indicated that high intensity soil surveys should be used to expose any problem soil to the engineer and not as the final decision in building location. This statement as to the limitations and purpose of soil surveys carries a warning to all involved in soil survey and its interpretations.

The foregoing discussion has illustrated the use of the basic soil survey in making interpretations for a variety of engineering uses. It is apparent that interpretations of soil surveys can be made for any number of specified purposes provided that the proper efforts are made to meet the specified objectives and that limitations of the interpretations are reported.

#### Soil Survey Interpretations for Recreation Site Development

The increasing demand for land and outdoor recreation areas and the implications of this demand on the natural resource base have previously been discussed. Soil is a basic resource and thus is the key consideration in any form of land use (Dotzenko et al., 1967). The kind of soil dictates, to a large degree, the type and location of recreational facilities. Some soils are undesirable sites for campsites, play areas, or picnic grounds. Therefore, there is an obvious need for soil survey information when designing recreation areas (Montgomery and Edminster, 1966; Stevens, 1966).



The successful use of soil survey interpretations in other facets of land use planning has been previously discussed. The soils within an area are mapped and classified without regard for existing or expected types of use. Each soil delineated is defined so that the information is available for planning different kinds of land use. Many of the soil properties that affect agricultural and engineering use also affect recreational use. The only difference lies in the interpretation of the effects these properties have on recreational use.

As early as 1945, Lutz realized the use of forest areas for recreational purposes by large numbers of people resulted in changes in the physical properties of the soil. In studies of picnic grounds he found that bulk density was greatly increased, pore volume and air capacity were decreased, and permeability was significantly reduced as a result of trampling. La Page (1962) reported similar findings in three New Hampshire State Parks. Dotzenko et al. (1967) found significant correlations between intensity of use and soil properties such as bulk density, organic matter content, and moisture content in Rocky Mountain National Park. As Bohart wrote in 1968:

"Outdoor recreation areas must be designed for use without undue deterioration of soil, water, and vegetative resources. Dead and dying vegetation, compacted and eroded soil . . . . are indicators of heavy use and poor management. These are also indicators of inadequate facilities and poor design. . . .

Incessant demand for recreational facilities is no excuse for permitting use without proper development."



The use of soil survey information in recreation site design would eliminate or at least minimize the problems suggested by Bohart. Montgomery and Edminster (1966) have discussed some of the soil limitations for recreational use. They listed wetness, susceptibility to flooding, permeability, slope, surface texture, depth to bedrock, and stoniness as some of the soil limitations and qualities that affect recreational use. From interpretations of these soil properties they suggested guides to be used in designing recreation areas with campgrounds, picnic areas, buildings, playgrounds, and hiking trails. Montgomery and Edminster also stress the importance of placing the proper perspective on the use of soil survey interpretations in recreational planning. It is emphasized that interpretations are based on soil features only and do not include such factors as location, aesthetic values, and nearness to population centres. It was concluded that a properly interpreted soil survey is a useful guide for general recreational planning and in site selection, planning, and design of recreational facilities.

Stevens (1966) demonstrated very effectively the use of soil survey interpretations in recreation site design. For a small campground area a series of three diagrams showed the layout before and after soil survey information was available. In the original design forty-five family units were planned. After soil survey information became available this number was reduced to thirty-three units. It was judged that, even though twelve units



were lost, the cost of maintenance and rehabilitation from expected degradation far outweighed the advantage of additional family units on these soils. And of equal importance, the revised design was found to be more compatible with the existing landscape features. In conclusion Stevens stated that "a soil survey and the interpretations derived from survey data assist the manager to plan, design, develop, and maintain recreation areas."

The suggested guides presented by Montgomery and Edminster (1966) and the use of soil survey information demonstrated by Stevens (1966) are an excellent beginning to developing comprehensive soil survey interpretations for recreational site planning. However, only the "surface" has been touched. There is much need for continued research into the effects of recreational use on soil properties. Montgomery and Edminster and Stevens have included only a portion of the important soil properties in their interpretations. Such soil qualities as trafficability and shrink-swell potential will undoubtedly affect the suitability of a soil for campground use. Trafficability, in particular, should be an integral part of any soil survey interpretations for recreational planning, since the intensity of use of any recreational area must be governed to prevent deterioration of the natural resource base.

Thus, for recreation site design, as for agricultural and engineering purposes, soil survey interpretations developed from the basic taxonomic soil survey are essential to obtain maximum use without subjecting the natural resource base to any permanent damage.



## Summary

The growing need for outdoor recreational areas was discussed. Several of the methods used at the present time for the classification of recreation lands were discussed and it was found that these were developed for inventory purposes rather than recreation area design and management. It was concluded that suitable interpretations of soil survey information may possess the necessary mechanism to assist in recreational area design.

A discussion of the successful uses of soil survey information and its limitations suggested the possibility of developing a similar technique for use in planning recreational areas. A review of the developments in soil research for recreational purposes showed that soil survey information and interpretations for recreational purposes was not only feasible but also essential.

It was concluded that soil survey interpretations developed with the proper perspectives in mind could provide the basic mechanism for designing outdoor recreational areas and facilities.



### III. DESCRIPTION OF THE STUDY AREAS

#### Miquelon Lake Provincial Park

Miquelon Lake Provincial Park is located on the southern and eastern shores of the larger Miquelon Lake approximately 40 miles southeast of Edmonton and is accessible by a two lane paved highway (Fig. 1). It is found in the east half of section 19, section 20, the south half of section 21, and the east half of section 29 in Tp 49, R20, W4M (Fig. 2). The park encompasses an area of approximately 1,200 acres.

The history of Miquelon Lake is well documented (Nyland, 1970). Descriptions have been made of its beauty, richness in wildlife, and fine beaches ever since the first settlers came to Alberta. Many writers have documented the decline of Miquelon Lake and have suggested various reasons. One of the main reasons for the decline of the lake level is its extremely small watershed (Nyland, 1970). Uncontrolled land clearing and water diversion from the lake both have contributed to the removal of water from the watershed. The climate in the area is such that the annual rate of evaporation exceeds the annual rate of precipitation by 10 cm, thus it is important to prevent surface runoff. Legal land



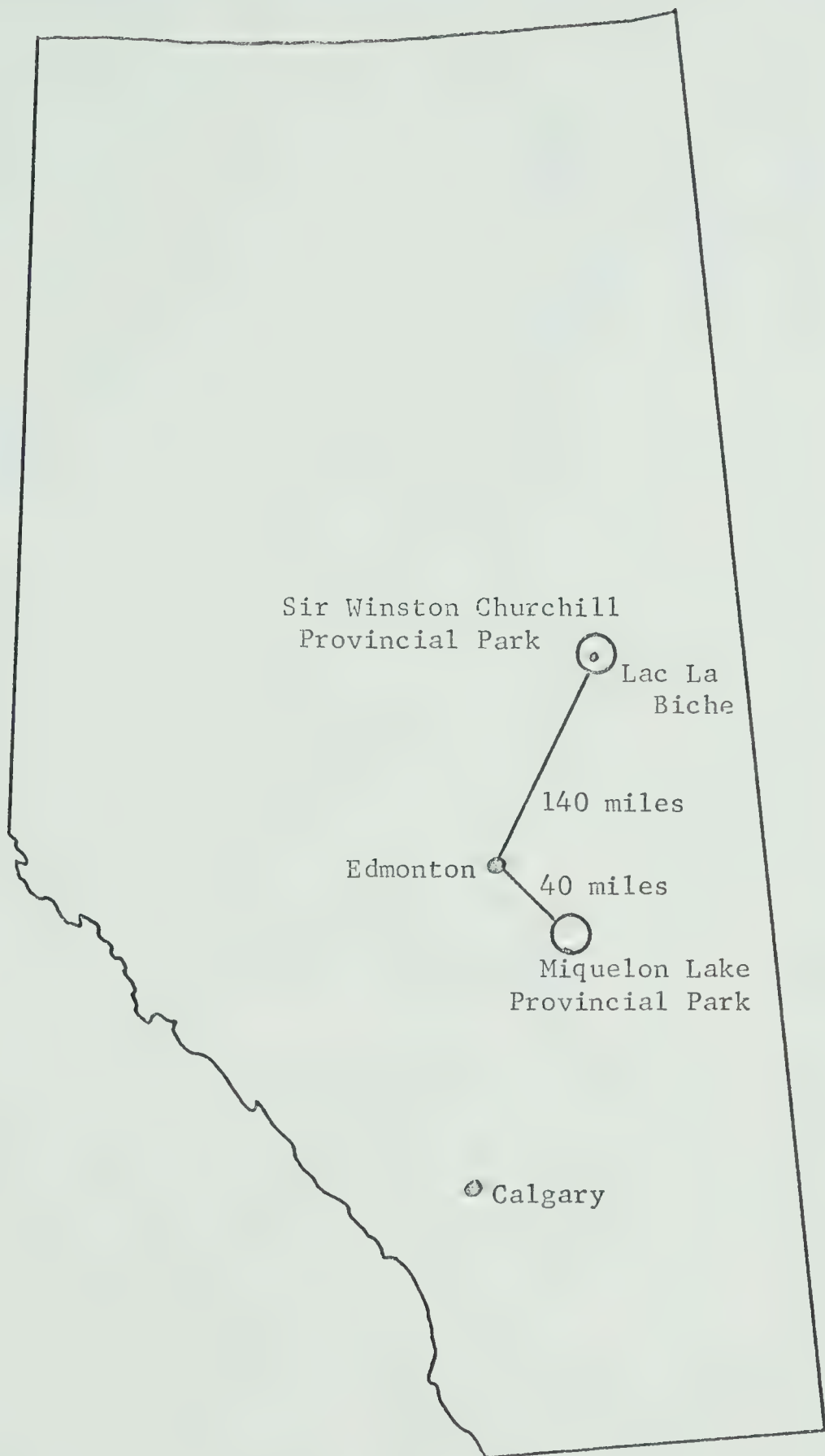


FIGURE 1. Location of the Study Areas



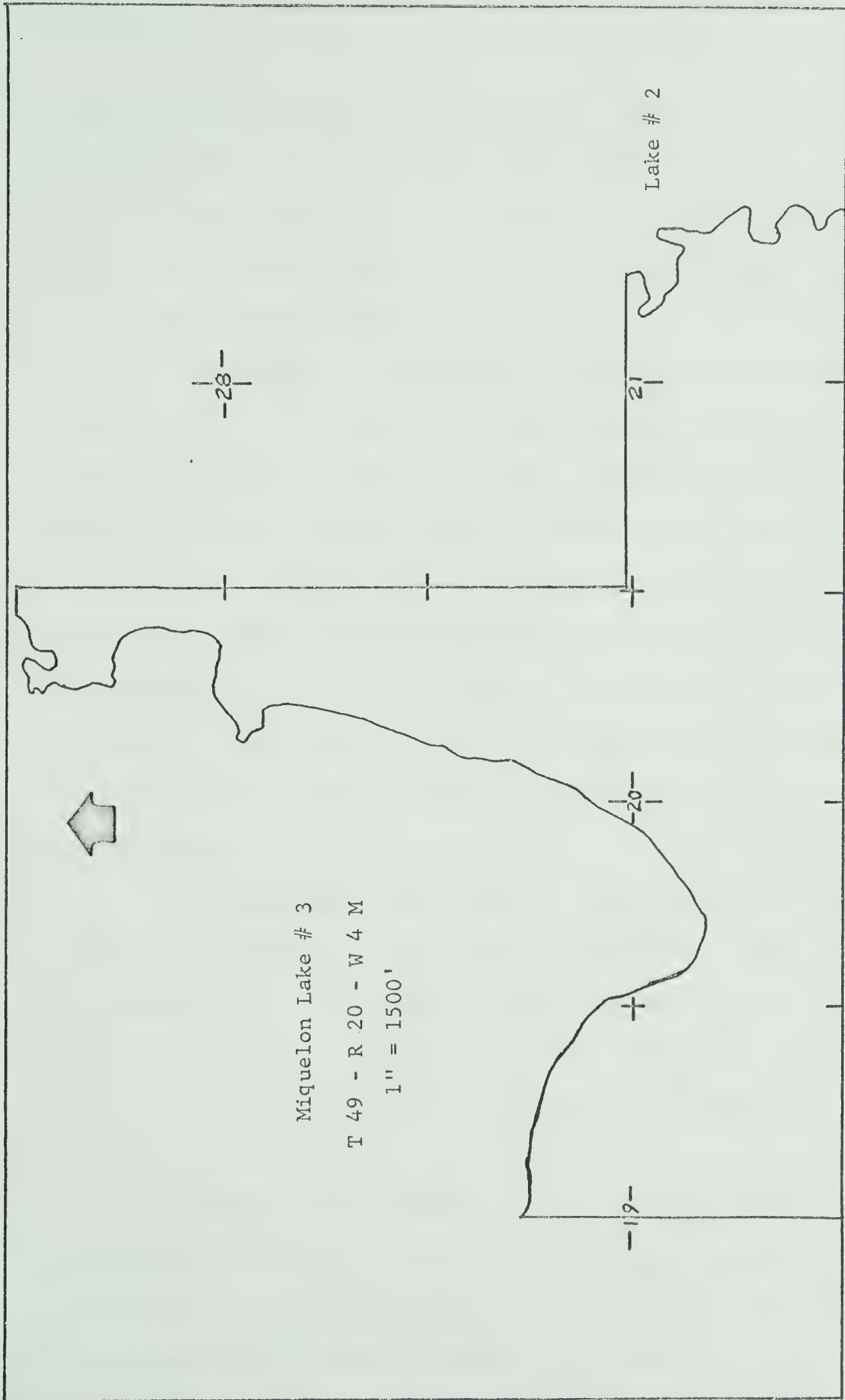


FIGURE 2. Location of Miquelon Lake Provincial Park



survey in 1969 found the lake level to be 2,502.5 feet above mean sea level which is 17.5 feet lower than the level recorded in 1901 (Nyland, 1970) indicating surface runoff has not been controlled. From personal observation the decline in lake level has continued through 1970.

The Master Plan Programme for Miquelon Lake Provincial Park as set out by the Provincial Parks Planning Branch of the Department of Lands and Forests suggests a design concept to provide an aesthetic balance between development and nature. Two major factors are considered to influence the amount of park development. These are the declining lake level and the supply of culinary water. By 1967 the supply of water was considered inadequate. The present plan provides accommodation for 100,000 overnight and day users and development is continuing at an almost alarming rate.

The arrangement of trailer and tenting facilities (Fig. 3a) stipulates a minimum of 20 feet between trailers and eight tents per design circle. The location and arrangement of other facilities provided is also shown in Figures 3a and 3b. The natural marina shown in Figure 3b will soon be a mud flat if the water level continues to decline.

Miquelon Lake is situated in the southern reaches of the Cooking Lake moraine and is underlain by Edmonton formation bedrock. The till in the area is of Edmonton formation origin. The soils are dominantly Gray Luvisols (Bowser et al., 1962).



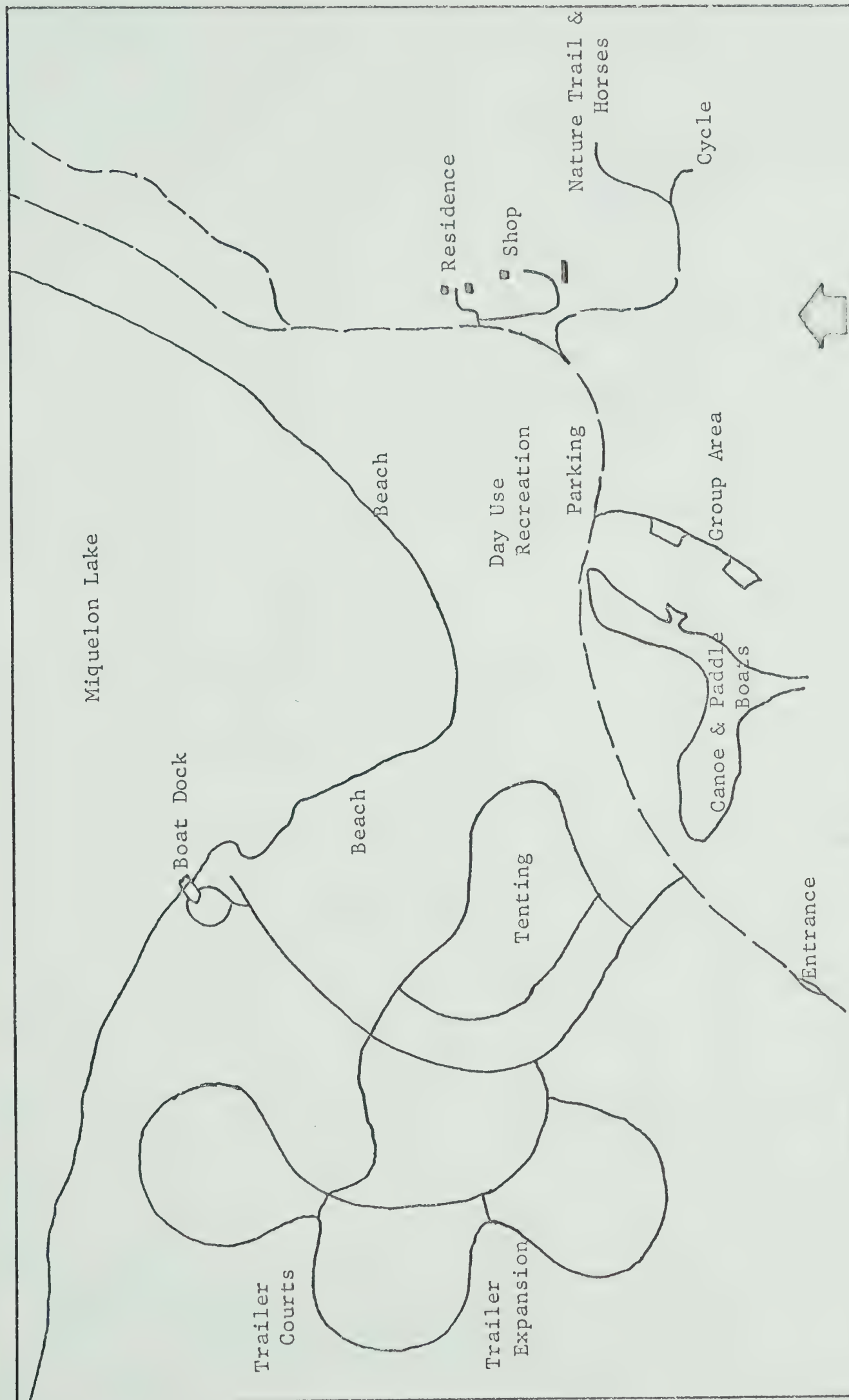


FIGURE 3a. Arrangement of Recreation Facilities at Miquelon Lake Provincial Park, Main Beach Area



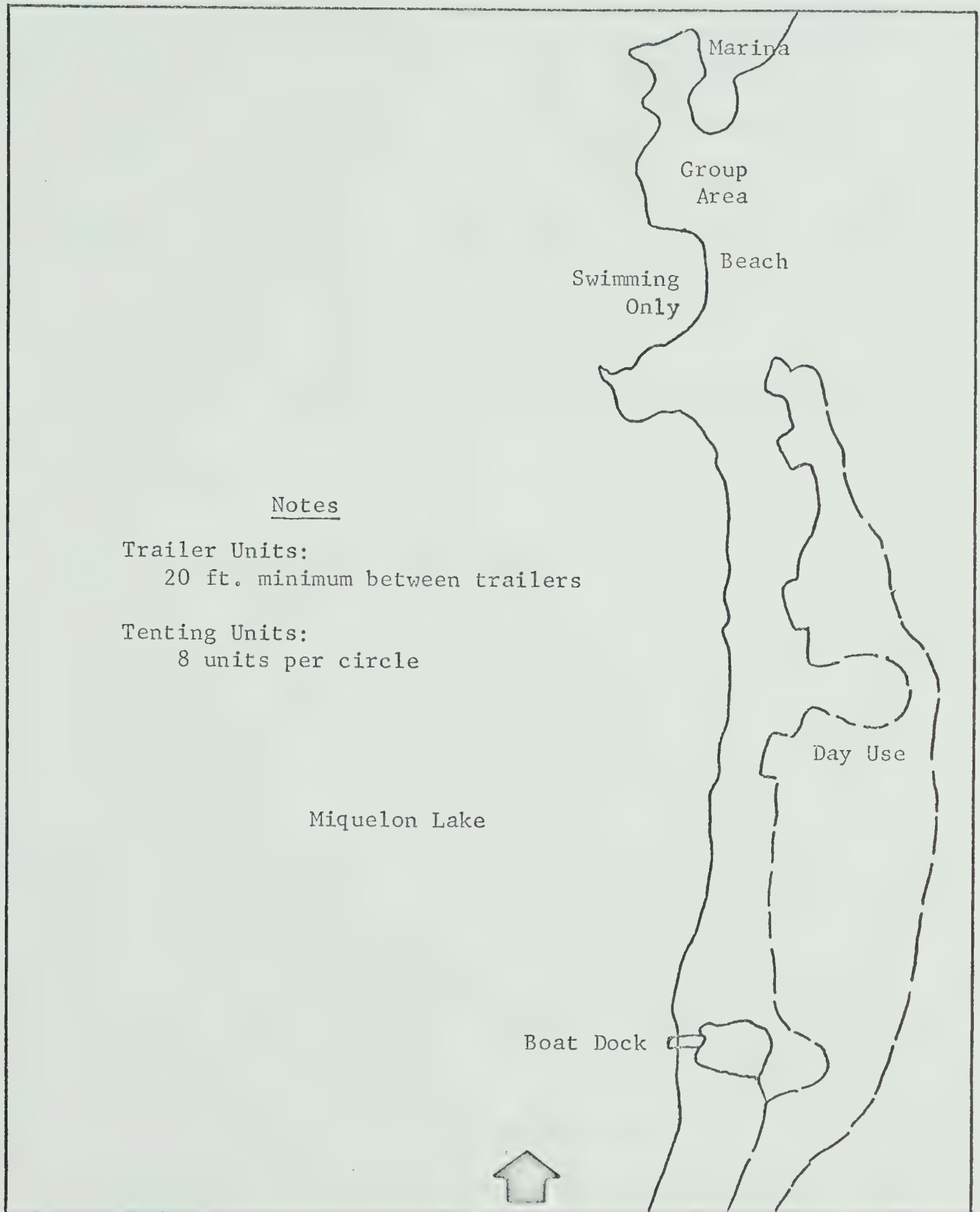


FIGURE 3b. Arrangement of Recreation Facilities at Miquelon Lake Provincial Park, Upper Beach Area



The most abundant species of trees in the park are aspen poplar (P. tremuloides) and balsam poplar (P. balsamifera). The understory consists mainly of willow (Salix spp.), dogwood (C. stolonifera), chokecherry (P. virginiana), wild rose (Rosa spp.), saskatoon (A. alnifolia), raspberry (R. strigosus), hazelnut (C. cornuta), and gooseberry (R. hirtellum). A variety of wildlife (deer, coyotes, rabbits, and beavers) is found within the park and the lake lies in the path of the spring and fall migration routes of geese, swans, and cranes. Due to the alkalinity of the lake, fish are nearly absent.

#### Sir Winston Churchill Provincial Park

Sir Winston Churchill Provincial Park is located on Big Island in Lac La Biche approximately five miles northeast of the town of Lac La Biche and about 140 miles northeast of Edmonton (Fig. 1). The last 40 miles of the highway from Edmonton are not paved. The park is found in parts of sections 20, 29, 30, and 31, Tp 67, R13, W4M and parts of sections 25 and 36, Tp 67, R14, W4M (Fig. 4). Big Island is connected to the mainland by a smaller island and a vehicle causeway. The park encompasses a total area of 591.4 acres.

Lac La Biche has played an important role in the development of northeastern Alberta. Since waterways provided the main means of transportation in the early days, Lac La Biche was strategically located. Accessibility was easy overland from



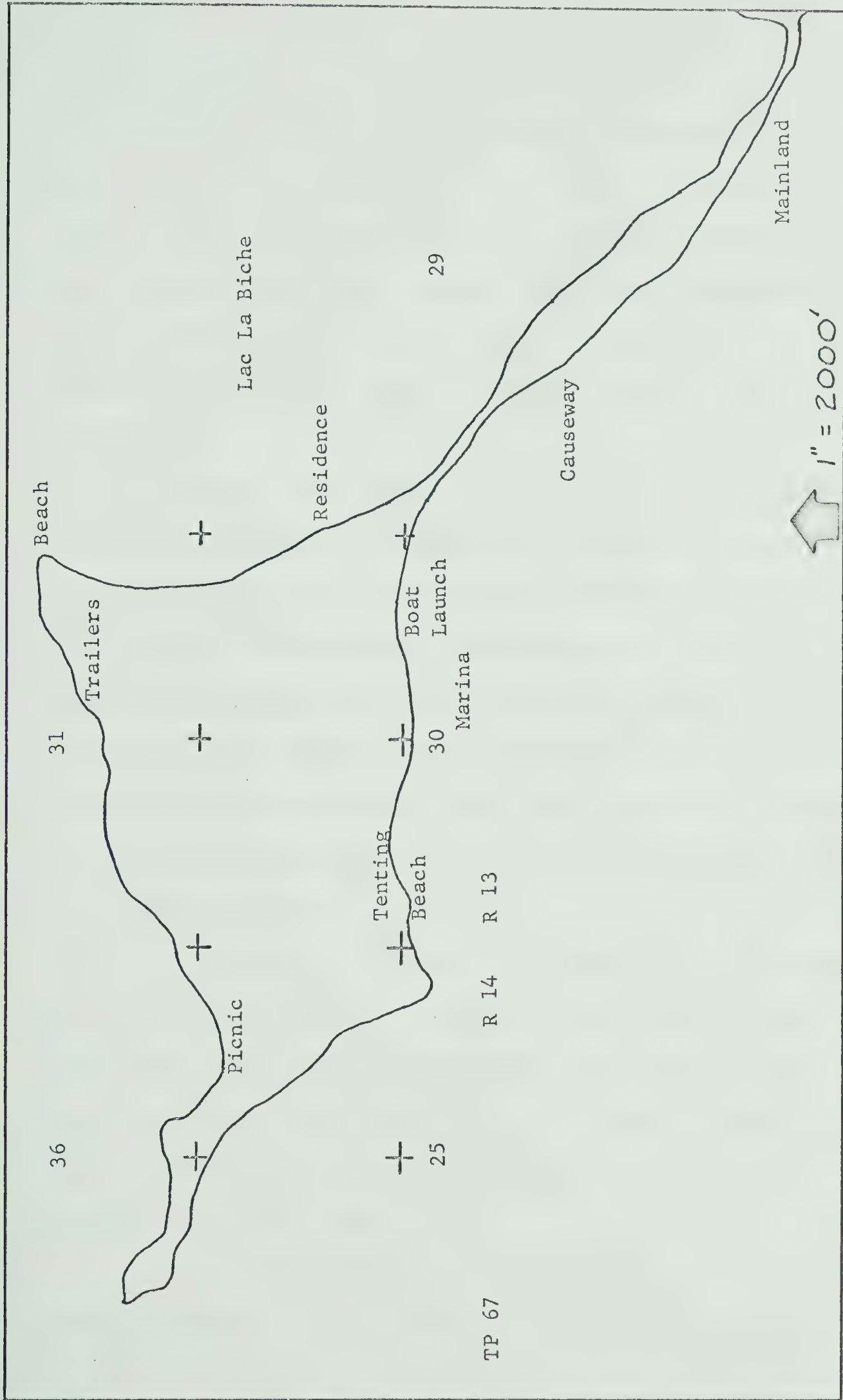


FIGURE 4. Legal Location of Sir Winston Churchill Provincial Park and the Arrangement of Recreation Facilities



the south and then the course of waterways leading from the lake can be followed to the Athabasca River, the MacKenzie River, and finally to the Arctic Ocean. Over the years this orientation to water-dependent travel and employment has come to influence the present inhabitants in both their work and recreation. The orientation to water has also had a major influence on the design of the park.

The Master Plan Programme for the park as set out by the Parks Planning Branch of the Department of Lands and Forests suggests a design concept evolving from a few basic characteristics of the island. The elements of beautiful mature forests, excellent beaches, and nature viewing combines with the atmosphere of adventure which accompanies land surrounded by water. There are three major beach areas on the island. By using them as a means to divide trailers, tenters, and picnickers the major use areas are separated (Fig. 4).

The location of the marina is dictated by an interesting and rare natural phenomenon. A colony of pelicans makes its summer home on two small islands north of Big Island. Their preservation is extremely important and therefore all boat traffic will be restricted to the south side of the park and away from the pelican colony.

It is hoped that the park will add to the resort atmosphere presently being promoted in the town of Lac La Biche.



By complementing the town's facilities it is possible for the park to become a compatible recreation outlet in northeastern Alberta.

Sir Winston Churchill Provincial Park being situated on an island has very complex soil patterns not common to the mainland. The soils are dominantly Gray Luvisols and the underlying bedrock probably is a member of the Lea Park formation. The climate, due to the surrounding body of water, will be slightly different from the mainland.

Three distinctive vegetative areas are found on Big Island: (1) aspen poplar - birch; (2) birch; and (3) white spruce - balsam fir. The trees are generally approaching maturity most likely due to isolation (no burning). The undergrowth in all areas is very dense and dead-fall in the spruce - fir area makes walking extremely difficult. Many species of wildlife live on the island (deer, rabbits, and bear) and the lake is the home of many species of waterfowl. Among the many species that nest in the area are the pelican, the blue heron, the western grebe, the loon, the sandhill crane, and a few uncommon species such as the bald eagle and the osprey. The lake is also home to many species of fish.



#### IV. METHODS

##### Soil Survey and Mapping

Detailed soil surveys were conducted on the two selected Alberta Provincial Parks. These surveys were carried out on a grid basis with soil observations made at 50 to 100 metre intervals. The soils were classified according to the Canadian System of Soil Classification (N.S.S.C., 1968). Soil mapping units consisted of phases of soil series. Uncontrolled aerial photograph mosaics (Scale 1 cm ~ 72 m) were used for base maps. The mosaics were made from modified infrared photos taken with a minus blue filter. Photointerpretation on stereo pairs of 1:12,000 aerial photographs aided the projection of soil boundary lines between points of observation.

##### Sampling

Soil profiles representative of mapping units were sampled in each of the Provincial Parks for chemical and physical characterization. Pits at the sampling sites exposed an area larger than the dimensions of the pedon. The soils were described morphologically and sampled according to the horizon sequence within the pedon. A control section of 1.8 metres was used where possible.



The collected samples were air-dried and the soil peds were then crushed in a steel roller mill to pass a 2 mm. sieve and stored in non-sealing screw top containers.

### Chemical Analyses

Soil Reaction. pH was determined on a saturated soil paste as outlined by Doughty (1941) using a Beckman Model Zeromatic pH meter equipped with a glass and calomel electrode.

Calcium Carbonate Equivalent. A modification of the procedure described in A.O.A.C. (1955) was used to determine  $\text{CO}_3\text{-C}$ . The  $\text{CO}_2$  evolved by treating the sample with  $\text{H}_2\text{SO}_4$  and  $\text{FeSO}_4$  was absorbed in ascarite and determined gravimetrically.

Organic Carbon. Organic carbon was determined as the difference between total carbon and inorganic carbon ( $\text{CaCO}_3$  equivalent). The method used was a dry combustion procedure using a Leco induction furnace as outlined in Methods of Soil Analysis (Allison et al., 1965). The  $\text{CO}_2$  evolved was determined gasometrically with a Leco Model 577-100 carbon analyser.

Exchange Acidity. Exchange acidity was determined by leaching the soil with 0.5 N barium acetate adjusted to pH 7.0 and titrating



the leachate with standardized NaOH as suggested by Brown (1943).

Exchangeable Cations and Exchange Capacity. The exchangeable cations were extracted from the sample with 1 N ammonium acetate adjusted to pH 7.0 as outlined in A.O.A.C. (1955). The exchangeable cations ( $\text{Ca}^{++}$ ,  $\text{Mg}^{++}$ ,  $\text{K}^+$ ,  $\text{Na}^+$ ) were determined with the Perkin Elmer Model 303 Atomic Absorption Spectrophotometer. The cation exchange capacity was determined by extraction of adsorbed  $\text{NH}_4$  with 1 N NaCl and distillation of the extract according to the method outlined in A.O.A.C.

Soluble Salts. The soluble cations were extracted from a saturated soil paste according to the procedure outlined in U.S.D.A. Handbook 60 (1954). The saturation extract was obtained by suction. The soluble cations ( $\text{Ca}^{++}$ ,  $\text{Mg}^{++}$ ,  $\text{Na}^+$ ) were determined with the Perkin Elmer Model 303 Atomic Absorption Spectrophotometer. Sulphate, the only anion measured, was determined with the conventional turbidimetric method employed by the Alberta Soil Survey Laboratory.

Electrical Conductivity. The electrical conductivity of the saturation extract was measured with a direct reading Solu-Bridge Model RD-26.



## Physical Analyses

Particle Size Analysis. A modification of the procedure outlined by Bouyoucos (1961) for particle size analysis was used. Salts were removed from the soil with repeated washing; organic matter with successive treatments of 35 per cent  $H_2O_2$ ; and  $CaCO_3$  with the addition of excess 0.1 N HCl. Hydrometer readings were taken at 12 intervals beginning at 30 seconds and ending at 24 hours. The 2.0 - 0.05 mm fraction was wet sieved in a nest of sieves for the U.S.D.A. sand size separates. The percentages of sand, silt, and clay were based on the oven-dry weight of salt-free, organic matter-free, and carbonate-free fine earth fraction ( $<2.0$  mm).

Atterberg Limits. Liquid limit, plastic limit, plasticity index, and liquidity index of the Ae, upper Bt, and C horizons of the profiles were conducted according to the procedure outlined in the A.S.T.M. Book of Standards (1964).

Bulk Density. Bulk density was obtained according to the core method described by Bradfield and modified by Lutz (1947). The cores used had an inside diameter of 5 cm. Where coarse fragment prevented the extraction of an undisturbed core the "rubber balloon method" using a Soiltest Volumeasure was employed (Blake, 1965). The bulk density measurements reported are representative of the fine earth fraction of the sample which was achieved as follows.



After the samples were oven-dried and weighed, the material was slaked in a solution of dispersing reagent (Calgon) and subsequently passed through a 2 mm sieve. The coarse fragment fraction thus separated was oven-dried, weighed, and this value was subtracted from the weight of the soil. The volume of the coarse fragment was then determined by displacement of water in a graduated cylinder. The volume of the coarse fragment was subtracted from the volume of the soil. Bulk density was then calculated using the weight and volume values obtained after subtraction of the respective coarse fragment values.

Soil Strength. Bearing capacity measurements were obtained using a Soiltest pocket penetrometer (Davidson, 1965). Penetrometer values were determined in the field by injecting the penetrometer horizontally in fresh exposures of the Ae, upper Bt, and C horizons. The average and the range for 25 penetrometer readings are reported for each horizon.

#### Soil Moisture Analyses.

Natural moisture was determined by oven-drying field-moist samples overnight at 105°C. The moisture content reported with the bulk density values is also a measure of natural moisture.

Hygroscopic moisture was determined by oven-drying air dry samples overnight at 105°C.



15-bar moisture was determined by the method of Richards (U.S.D.A. Handbook 60, 1954) using a pressure membrane apparatus with a cellulose casing membrane. Soil passing a 2 mm sieve was placed in rubber retaining rings 1 cm in height and about 6 cm in diameter.

1/3-bar moisture was determined by the method of Richards (U.S.D.A. Handbook 60, 1954) using a pressure plate apparatus.

1/10-bar moisture was determined with the pressure plate apparatus (U.S.D.A. Handbook 60, 1954) on samples containing more than 70 per cent sand.

Saturation capacity was determined on the samples for which soluble salts are reported. The saturated paste was subsampled before extraction of the salts, and saturation capacity was considered to be the loss in weight of the sample after drying to a constant weight at 105°C.

### Mineralogical Analyses

Preparation of Clay Samples. Separation of the total clay fraction ( $< 2$  microns) from the samples was achieved by gravity sedimentation as outlined by Jackson (1949) and modified by Pawluk (1961). The initial treatment prior to separation of the clay fraction consisted of removing the carbonates with 0.1 N HCl.



The carbonate-free sample was then brought into suspension by stirring. The separation of the clay was accomplished by repeated decantation of the upper 8 cm of suspension after standing for approximately 6 hours as determined from Stoke's Law (Baver, 1959). The clay fraction was flocculated with magnesium acetate followed by successive washings with distilled water and then 95 per cent ethanol to remove the acetate. The Mg-saturated clay suspension was then used to prepare samples for x-ray analysis.

X-ray Analysis of Clay Minerals. The clay samples were prepared for x-ray diffraction analysis according to the method of Kittrick (1961). Essentially this entailed taking a few drops of clay suspension, placing it on a glass slide, and allowing the suspension to dry. Three slides of each sample were prepared. One slide of each sample was kept for air-dry analysis. Another slide of each sample was glycolated by placing the prepared slides in a saturated atmosphere of ethylene glycol at 60°C. for 48 hours. The third slide of each sample was dehydrated by heating to 550°C. for 2 hours.

A Philips x-ray diffractometer with a high-angle goniometer was used for identification of the clay minerals present. The x-ray generator was operated at 40 k.v. and 20 m.a. using CuK radiation with a nickel filter. Scanning speed was one degree  $2\theta$  per minute and the chart speed was one cm per minute. The recorder settings were 1,000 counts per second with a time constant of 4 for all diffractograms. All slides were scanned to an angle of  $30^\circ 2\theta$ .



## V. RESULTS AND DISCUSSION

### Soil Characteristics and Patterns

#### Miquelon Lake Provincial Park.

Physiography. The park is situated in the southern reaches of the Cooking Lake moraine. The topography and landform patterns are typical of a dead-ice moraine. Very irregular "knob and kettle" topography dominates with lesser amounts of small, level lacustrine basins and beach ridges around the lake shore. With the exception of the lacustrine and beach areas the land varies from gently rolling in the west to severely rolling and hummocky terrain in the eastern and northern portions of the park.

The morainic area is characterized by hills with short and steep slopes that are separated by depressions. Some of the depressions have permanent water, however there is evidence that most are receding. The depressions without water are characterized by a variety of hydrophytic vegetation. It appeared that those depressions that have been dry for the longest period of time have less surface organic accumulation than the ones most recently exposed. Tree vegetation on the upland areas is dominantly aspen poplar. Since the landform is glacial in origin, the main surficial



deposit is till. The till is derived from the Edmonton bedrock formation (Bowser et al., 1962).

All the till within the park is considered to be of the same origin (Appendix I A-5 and I C-5). However, an area was separated where the till is much coarser in texture and contains more coarse fragment (Appendix I C-3) than the typical till of Edmonton formation origin (Bowser et al., 1962). This area was found to have more irregular and more frequent knobs and kettles than the remaining till areas. The till area closest to the lake appears to be finest in texture and has the least coarse fragment (Appendix I A-3 and Fig. 5). This area is characterized by less irregular and generally more gentle topography.

The lacustrine flats are found mainly in the southwestern portion of the park and are characterized by a dark color, a high content of silt and clay, and a high salt content. Some small depressions in the northwestern portion contain lacustrine deposits. The lacustrine flats are generally poorly drained and characterized by grass vegetation with balsam poplar and willow around the edges. All of these areas were once submerged by Miquelon Lake. Much of the upland area in the extreme southwestern portion is characterized by thin lacustrine deposits (<90 cm) overlying the till.

The beach deposits along the shore of Miquelon Lake are extremely variable. Generally, these deposits occur as ridges parallel to the shoreline. Where the old shoreline is the steepest the beach deposits are gravelly and where the old shoreline is less



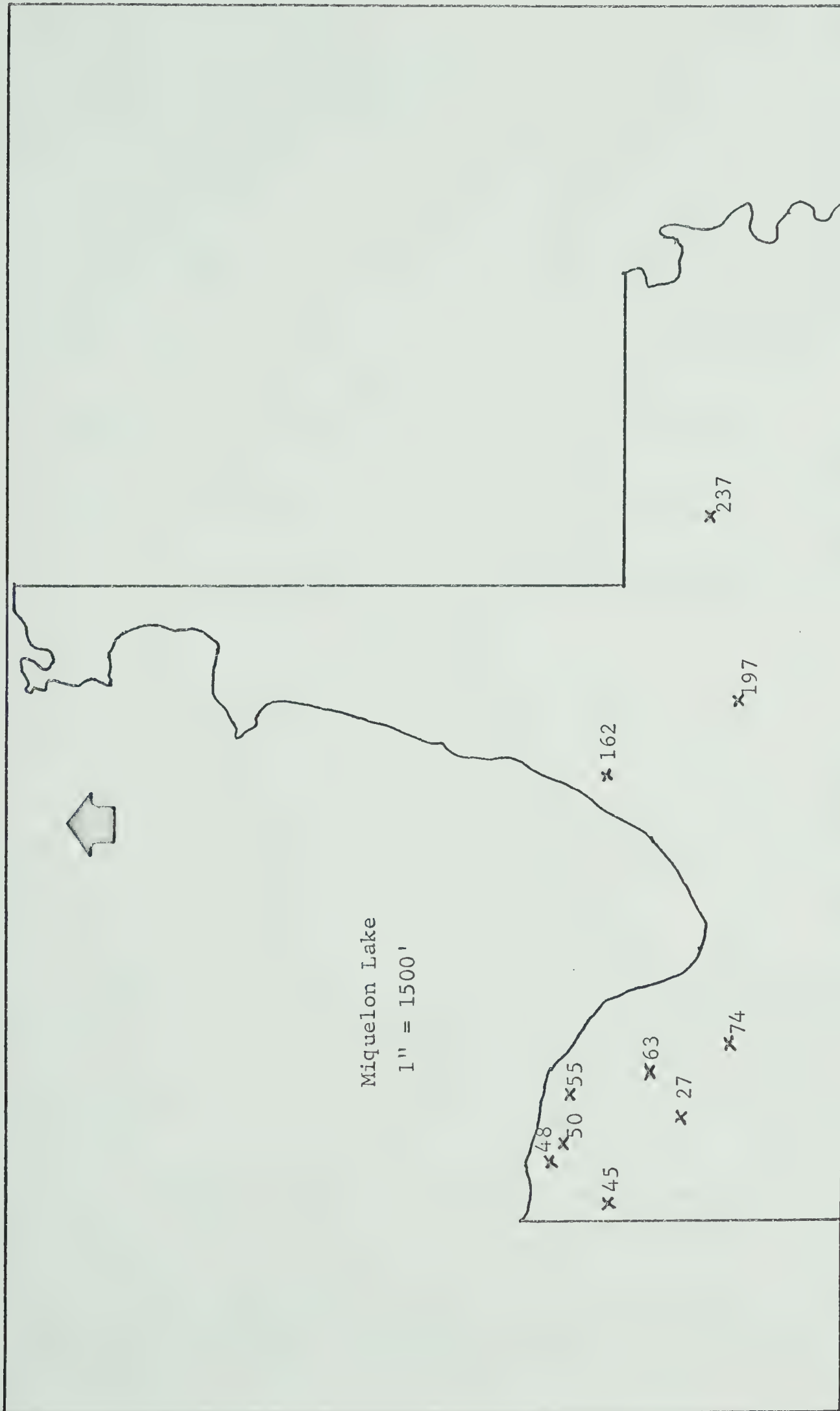


FIGURE 5. Locations of the Sampling Sites at Miquelon Lake Provincial Park



steep the deposits are mainly fine and medium sands. It was found possible to make separations according to depth of beach deposit overlying the till and lacustrine deposits. These areas are generally poorly drained where the beach deposit is shallow. Where the beach deposit is deepest the vegetation is dominantly balsam poplar and willow with some buffalo-berry (S. canadensis). In the areas where the beach deposit is shallowest (<15 cm) buffalo-berry is dominant with very little other vegetation. Much of this area is very stony on the surface (almost a boulder pavement) and the stones frequently are crusted with thick layers of salt and lime (up to 3 cm) indicating the alkalinity of the lake water.

Soils. The enclosed soils map presents the distribution of soils in Miquelon Lake Provincial Park. Soils are delineated according to phases of soil series except for one undifferentiated gleysol and the organic soils. The organic soils are delineated on the basis of their Great Group classification. A total of 20 soil series are defined on the map. The mapping units used were derived from the series according to the phase classes outlined in the map legend. The mapping units are considered to be 90 per cent pure.

Soils belonging to six Orders in the Canadian classification system are identified in the park. Luvisolic soils are dominant with lesser areas of Chernozemic, Gleysolic, Solonetzic, Regosolic, and Organic soils being present. Man-altered areas



(parking lots, etc.) are delineated and symbolized by "X". Locations of representative soils of dominant mapping units sampled are shown in Figure 5. Detailed morphological descriptions and analytical results for each of the sampled profiles are presented in Appendix I. Photographs of profiles and landscapes are presented for three of the largest mapping units sampled (Appendix I).

The soils in the moraine area follow a toposequence. The Luvisolic soils occupy the better drained positions. On the tops of hills and down to about mid-slope, the dominant soils are Orthic Gray Luvisols. From mid-slope to the bottom, Orthic Dark Gray Luvisols dominate. At or near the bottom of slopes, Gleyed Dark Gray Luvisols are found but only in very limited areal extent. These grade quickly into Gleyed Dark Gray Chernozems.

The Gleyed Dark Gray Chernozems are found in the low lying areas between the base of slopes and the depressions. Gleysolic soils are found around the perimeter of the depressions and organic soils occupy the lowest lying portions of the depressions. In cases where surface accumulation of organic matter is least, peaty phases of Humic Gleysols and Humic Eluviated Gleysols dominate. In areas close to the lake, Low Humic Eluviated Gleysols are found indicating the water receded rather quickly and thus no organic deposit occurs.

The Regosolic soils are limited to the recent beach deposits. The soils in this area underlain by till and lacustrine



deposits generally fit the Rego Gleysol subgroup of the Gleysolic Order in the Canadian classification system.

The detailed morphological descriptions and analytical results for the three Cooking Lake series (Orthic Gray Luvisol) profiles are found in Appendix I A-2 and 3, I B-2 and 3, and I C-2 and 3. These soils are characterized by a high base saturation and strongly acid to mildly alkaline pH values. Calcium is the dominant cation on the exchange complex of each horizon. The pH values for the Ae horizons range from 5.9 to 6.6, for the Bt horizons from 4.9 to 5.9, and for the Ck horizons from 7.5 to 7.8. The organic carbon content of the surface horizons is less than one per cent and the calcium carbonate equivalent of the Ck horizons is approximately six per cent.

Only in the soils lying close to the lake is there evidence of soluble salts in the lower horizons (Profile M. 55). In these cases the dominant salt is sodium sulphate (Appendix I A-3) and the electrical conductivity of a saturation extract of the Ck horizons is about 4.0 mmhos/cm. This profile is typical of the Cooking Lake series as defined by Bowser et al. (1962).

These soils show an accumulation of clay in the B horizons (Appendix I A, I B, I C). Profile M. 55 has the finest texture with about 40 per cent clay in the B horizon and 30 per cent clay in the C horizon. Profile M. 237 is slightly coarser in texture than the typical Cooking Lake soil. This profile has approximately 30 per cent clay in the B horizon and 20 per cent clay in the C



horizons. This is the soil developed on the coarse till previously discussed. It was not defined as a new series since the x-ray analysis (Appendix I A-5 and I C-5) showed there was no mineralogical difference between the fine and coarse members. The x-ray diffractograms showed montmorillonite to be the dominant clay mineral present with lesser amounts of illite, kaolinite, and quartz. Therefore, the soils developed on the coarse member of the Edmonton formation till were delineated as a coarse phase of the typical Cooking Lake soil.

The Atterberg limits of the Cooking Lake soils show a direct relation to the clay content. The profile (M. 55) with the highest clay content has the highest liquid limit and plasticity index (Appendix I A-3). The profile with the lowest clay content has the lowest Atterberg limits. The bulk density values show an inverse relationship with clay content. This is similar to results found by other workers (Twardy, 1969) for Cooking Lake soils. The soil strength, as measured by the pocket penetrometer, for the C horizons ranges from 3.37 kg/cm<sup>2</sup> (Profile M. 55) to 4.3 kg/cm<sup>2</sup> (Profile M. 237). These values are comparable to those found by Twardy and are found to vary greatly with natural moisture content.

The laboratory moisture analyses also show a direct relationship to the amount of clay present. The natural moisture content appears to be the exception. Natural moisture content was determined at two times during the year, once in the late summer (August) while sampling for bulk density and once in late spring



(May). Generally, the natural moisture content is very near to the lower limit of plant-available moisture (15 bar moisture) in late summer and near or above the upper limit (1/3 bar moisture) during the spring.

The Dark Gray Luvisol (Uncas series) developed on till has similar characteristics (Appendix I D-3) to the Cooking Lake soils (I A-3). Morphologically it is different in that it has significant Ahe and AB horizons (Appendix I D-2).

The detailed morphological description and analytical results for the Monique series (Gray Solod developed on thin lacustrine deposits) profile are found in Appendix I E-2 and 3. These soils are characterized by a high base saturation and strongly acid to mildly alkaline pH values. Calcium and magnesium are the dominant cations on the exchange complex of each horizon. The pH values of the Ae horizons are about 5.5, the Bt horizons about 6.0, and the IICks horizons 7.5 to 7.7. The organic carbon content of the surface horizons is about 1.5 per cent and the calcium carbonate equivalent of the IICks horizon is slightly lower than the till described previously.



Morphologically the Monique soils have solonetzic tendencies (Appendix I E-2). A columnar macrostructure is evident in the Bt horizon. However, on a morphological basis this soil would not be classified in the Solonetzic order. Chemically, the profile sampled meets the requirements of the Solonetzic order (exchangeable Ca: exchangeable Na in Bt is less than 10).

The distribution of soluble salts with depth in the profile shows an accumulation of salts at a depth of 100 to 120 cm suggesting a groundwater discharge position in the landscape. The dominant salt present is sodium sulphate and the electrical conductivity of the IICks horizon approaches 7 mmhos/cm.

These soils show an accumulation of clay in the B horizons (Appendix I E-3). X-ray analysis (Appendix I E-5) shows montmorillonite to be the dominant clay mineral present. The clay content of the B horizons is generally greater than 50 per cent and the clay content of the underlying till is similar to that previously discussed for till of Edmonton formation origin.

The Atterberg limits of the lacustrine portion of the Monique profile (M. 27) are significantly larger than comparable horizons of the Cooking Lake soils. This is indicative of the higher clay content. The till portion of the profile has Atterberg limits similar to the Cooking Lake soils. The bulk density values do not show an indirect relationship with clay content. Bulk density values for the lacustrine portion of the profile are slightly higher than for the till portion indicating the more



compact nature of the lacustrine material. The soil strength of the B and IIC horizons (1.8 and 1.9 kg/cm<sup>2</sup>, respectively) is lower than those found in the Cooking Lake soils.

The moisture analyses, in this case, also show a direct relationship to clay content. Similar to the Cooking Lake soils, the natural moisture content approaches the lower limit of plant-available moisture in the late summer. However, in the spring the natural moisture content rarely approaches the upper limit (1/3 bar moisture).

There is a great variety of soils belonging to the Gleysolic order in the park. Most subgroups in the Canadian classification system are found on the three parent materials discussed.

The detailed morphological description and analytical results for the Onoway series (Orthic Humic Gleysol developed on till) profile are found in Appendix I F-2 and 3. This was the only gleysol developed on till that was sampled. These soils are characterized by a high base saturation and slightly acid to mildly alkaline pH values. Calcium and magnesium are the dominant cations on the exchange complex of each horizon. Generally, the pH values are found to increase with depth from 6.4 at the surface to approximately 7.5 at 1.6 m. The organic carbon content of the surface horizon is about 4.5 per cent and the calcium carbonate equivalent of the C horizon is between 4.0 and 4.5 per cent.

Morphologically, these soils have granular to "shotty" structures characteristic of groundwater discharge and/or a



fluctuating water table. Mottling throughout the profile is also evidence of a fluctuating groundwater table and poor internal drainage.

The presence of soluble salts in the lower horizons of the profile also suggests groundwater discharge although the concentrations are not as great as in profile M. 27 (Appendix I E-3). The dominant salt present is sodium sulphate and the electrical conductivity of the C horizon is slightly greater than 4 mmhos/cm.

The results from particle size analysis show an accumulation of clay in the B horizon, however field observations did not support this result. Some eluviation was observed but not enough to detect by manual texturing (Appendix I F-2). An error during the analysis is a probable explanation. The Ckg horizon has similar clay content to the till of Edmonton formation origin.

The Atterberg limits of the solum horizons are comparable to those of the lacustrine material in profile M. 27 (Appendix I E-3) indicating a higher clay content than is usual for the till in the park. The Ckg horizon, however, has a liquid limit and plasticity index similar to the till previously described (33 and 17 per cent, respectively). The bulk density of the Ckg horizon (1.7 g/cc) is similar to results reported elsewhere (Twardy, 1969) for till of Edmonton formation origin.

The moisture analyses show a direct relationship to clay content. Within the profile the 1/3 bar moisture and 15 bar moisture percentages increase with increases in clay content. Contrary to the well-drained till profiles (Cooking Lake series)



the natural moisture content in the late summer remains near the upper limit of plant available moisture. Only at depth (Ckg horizon) does the natural moisture content decrease late in the year.

The detailed morphological descriptions and analytical results for the gleysols developed on lacustrine materials are found in Appendix I G-2 and 3 and I H-2 and 3. These are the Raven series (Orthic Humic Gleysol) and the Westwind series (Saline Low Humic Eluviated Gleysol), respectively.

These soils are characterized by a high base saturation and medium acid to mildly alkaline pH values. Calcium and magnesium are the dominant cations on the exchange complex of each horizon. The exceptions are the Ah horizons of the Orthic Humic Gleysol where exchangeable hydrogen is high relative to other profiles discussed. This explains the strongly acid pH values (as low as 3.9 in Ahg<sub>3</sub> horizon) in this profile. The organic carbon content of the surface horizons of the Orthic Humic Gleysol range from 4.5 to 7.0 per cent. The Aeg horizon of the Saline Low Humic Eluviated Gleysol has an organic carbon content greater than five per cent. The calcium carbonate equivalent of the C horizons ranges from three per cent in the Orthic Humic Gleysol to greater than 10 per cent in the Saline Low Humic Eluviated Gleysol.

The inordinately high content of organic carbon in the Aeg horizon of the Saline Low Humic Eluviated Gleysol is explained by the high content of soluble salts. The soluble salt results show the presence of salts to the surface in this profile. The presence of soluble sodium salts causes dissolution of organic



matter from the surface resulting in the unusually high organic carbon content in the Aeg horizon. The fact that the organic carbon content does not continue high with depth suggests leaching in these soils is limited and that they are poorly drained due to groundwater discharge and/or the presence of a fluctuating water table. Chemically, this horizon meets the requirements of an Ahe horizon. However, the color requirements established by the N.S.S.C. (1968) are not satisfied.

The morphological description (Appendix I G-2 and H-2) supports the above evidence of groundwater discharge and/or the presence of a fluctuating groundwater table. The profiles are both intensely mottled and the structures found are granular or "shotty" to fine angular blocky. The mottles found are brightly colored and are located in a dull colored matrix.

The results of particle size analysis show a clay content comparable to other soils developed on lacustrine materials (40 to 60 per cent). The distribution of clay with depth in the profiles varies randomly suggesting stratification during deposition. The Btg horizon of the Saline Low Humic Eluviated Gleysol has less clay than the horizons immediately beneath, however morphologically it is a B horizon.

The Atterberg limits of the solum horizons are comparable to those reported for the Monique series. The exception is the Ahg1 horizon of the Orthic Humic Gleysol profile. The liquid limit of this horizon is relatively high (71 per cent) and may be explained by the presence of a large amount of organic matter which



has a high water holding capacity.

The bulk density values reported are significantly lower than those reported for the Monique series and are lower than values reported for the till profiles. This suggests the lacustrine material in these soils is less compact than their well-drained counterparts and supports the findings of other workers (Twardy, 1969) which indicates bulk density decreases with an increase in clay content.

The moisture analyses show a direct relationship to clay content. Within the profiles the 1/3 bar moisture and 15 bar moisture percentages increase with increases in clay content. Contrary to the Orthic Humic Gleysol on till the natural moisture content of these soils approaches the lower limit of plant available moisture in late summer. A possible explanation for this is the surface vegetation. The Orthic Humic Gleysol on till is under a relatively dense stand of aspen poplar, balsam poplar, and willow while the Gleysolics developed on lacustrine materials are under grass vegetation or low-density aspen and balsam poplar.

The detailed morphological descriptions and analytical results for the gleysols developed on beach deposits are found in Appendix I J-2 and 3 and I K-2 and 3. These are both members of the Wanisan series (Saline Rego Gleysol) which was phased according to the thickness of recent beach deposit overlying the till and lacustrine materials. Profile M. 50 (Appendix I K) represents Wanisan 2 and Profile M. 48 (Appendix I J) represents Wanisan 3.

These soils are characterized by a high base saturation



(near 100 per cent) and neutral to mildly alkaline pH values. Calcium is the dominant cation on the exchange complex of each horizon. The pH values tend to remain above 7 (7.4 to 7.8) for the profile with the least beach deposit. As the thickness of beach deposit increases pH values decrease to about 6.5. The organic carbon content of the surface horizons is nil and the calcium carbonate equivalent of the IICgk horizons ranges from three to five per cent and from six to nine per cent in horizons of secondary lime and salt accumulation.

The results of soluble salt analysis show the presence of salts to the surface in both profiles. The concentration of salts in the beach deposit portion of the profiles is low relative to the underlying till and lacustrine portion. The electrical conductivity of the underlying material ranges from three to six mmhos/cm.

Morphologically these soils show very little profile development. The location of these soils near to the lake suggests that they have been only recently exposed and thus time has been insufficient for any pedogenic processes to occur. Only one observation was made during the survey which indicated any profile development, and this was in an area of deepest beach deposit (Wanisan 5). Throughout the profile these soils show evidence of poor drainage. This evidence decreases as the thickness of beach deposit increases. Generally, mottling is absent in the upper 10 to 15 cm of the Wanisan 3, 4, and 5 phases.

The results of particle size analysis show a clay content



in the IIC horizons similar to the better drained till profiles (approximately 30 per cent). In the Wanisan 3 profile there is a layer (90 cm thick) of lacustrine material (65 to 70 per cent clay). This heterogeneity of the Wanisan series is characteristic. The field observations showed varying amounts of lacustrine material within the till. The upper part of the profile consists of 90 to 100 per cent fine and medium beach sands.

The Atterberg limits of the till portion of the profiles are comparable to those found for till of Edmonton formation origin. The liquid limit and plasticity index of the lacustrine layer in the Wanisan 3 profile are similar to those found in other profiles developed on lacustrine material. The 1/3 bar and 15 bar moisture contents are similar to the other till and lacustrine profiles sampled.

The other mapping units delineated on the soils map were not sampled because it was thought that their important characteristics and qualities can be inferred from the profiles sampled. Also, the remaining mapping units are of very limited areal extent with the exception of the Organic soils. The Organic soils were not sampled because their general unsuitability for recreational use seemed obvious.

#### Sir Winston Churchill Provincial Park

Physiography. Location of the park on an island constitutes a geomorphologically unique situation. Existing



landform patterns are not common to adjacent mainland areas. In general, the terrain of Big Island is regular and smooth. The land on the island rises most significantly in the south, the extreme west, and the northeast. The western end of the island is the most elevated. The shoreline is well defined and the steep banks rising from the shore are the most significant relief features. The bank disappears on the northeastern tip of the island where there is a gently sloping beach. On the southwestern tip of the island the peripheral bank goes inland exposing another gently sloping beach. Most of the remaining shoreline is bouldery.

The geology of Big Island is extremely complex. Characteristics and patterns found on mainland areas do not occur similarly on the island. The main surficial deposit on the island is till which is the only similarity with the surrounding mainland area. There are two tills found on the island, one on smooth topography and one on a small irregular area in the northeast. The dominant till (Grandin) which occurs on the smooth topography, is medium to fine textured, dark in color, has a shaly appearance, and is characterized by spruce - fir vegetation. It is probably derived from a member of the Lea Park bedrock formation.\* The other till, named Athabasca, occurs on the more irregular topography, is medium textured, has a brownish color, and is characterized by aspen poplar vegetation.

Contrary to the usual situation, the soils developed on the Grandin till occupy the low lying areas and in the areas where

\* Personal communication with Dr. W. W. Pettapiece, Soil Survey Staff, Canada Dept. of Agriculture, Edmonton.



the land rises lacustrine deposits dominate. On adjacent mainland areas, the opposite condition is the rule.

Throughout the till areas small areas of outwash and alluvial sand deposits are common. This condition appears to be characteristic of the Grandin till. The extreme western tip of the island is composed of alluvial sand deposits. The beach areas are composed of recently deposited coarse sands containing fine and medium gravels. The remainder of the shoreline consists of many cobbles and boulders with varying amounts of fine and medium beach sands.

The lacustrine deposits are found dominantly on the high points of the island and are characterized by a dark color, a fine texture, and stratification. All three vegetative types on the island are found on these materials. The x-ray analysis of Grandin till (Appendix II L-5) and lacustrine material (Appendix II N-5) showed no mineralogical differences in their clay fractions indicating the lacustrine material was of the same origin as the till.

Three small areas of medium textured alluvial-lacustrine deposits occur generally in drainage ways. These materials are characterized by alternate layers of silt and clay indicating stratification during deposition. Profiles developed on this material frequently had evidence of poor internal drainage (Appendix II U-2).



Soils. The enclosed soils map presents the distribution of soils in the park. Soils are delineated according to phases of soil series where possible. The areas that have an extremely complex soils pattern are delineated as complexes of phases. Scale of mapping prevented further delineation in these areas. The Organic soils are delineated as complexes of their Subgroup classification. A total of 20 soil series are defined on the map and are presented as phases according to slope class or thickness of organic deposit overlying the mineral soil. Two types of undifferentiated deposits and two complexes of Organic soils complete the list of mapping units used. The mapping units are considered to be 90 per cent pure.

Soils belonging to five Orders in the Canadian classification system are identified in the park. Soils of the Luvisolic order dominate with lesser amounts of Brunisolic,



Gleysolic, Regosolic, and Organic soils being present. Locations of representative soils of dominant mapping units sampled are shown in Figure 6. Detailed morphological descriptions and analytical results for each of the sampled profiles are presented in Appendix II. Photographs of profiles and their landscapes of four of the dominant mapping units sampled are found in Appendix II.

The Luvisolic soils on the island generally belong to the Orthic Gray or Dark Gray subgroups in the classification system. They are found in near equal proportion on both till and lacustrine parent materials. The lacustrine portion of the profile tends to be thin ( $\leq 90$  cm) on slopes leading off the high points in the topography. These soils do not adhere strictly to the topo sequence condition described for the soils found in Miquelon Lake Provincial Park. Other Luvisolic soils found in the park are gleyed members of their respective subgroups, and one Orthic Gray Luvisol occurs on the coarse textured alluvial deposits in the western tip of the park.

The Brunisolic soils found on the island are restricted to the coarse textured alluvial and outwash deposits. These generally belong to the Degraded Dystric subgroup. In the southwestern tip of the island the outwash deposits tend to be thin ( $\leq 90$  cm) and represent one of the complex situations found during the field mapping.

The Gleysolic soils are generally restricted to the fine textured lacustrine and medium textured alluvial lacustrine deposits and are found in the depressional areas. The dominant gleysolic



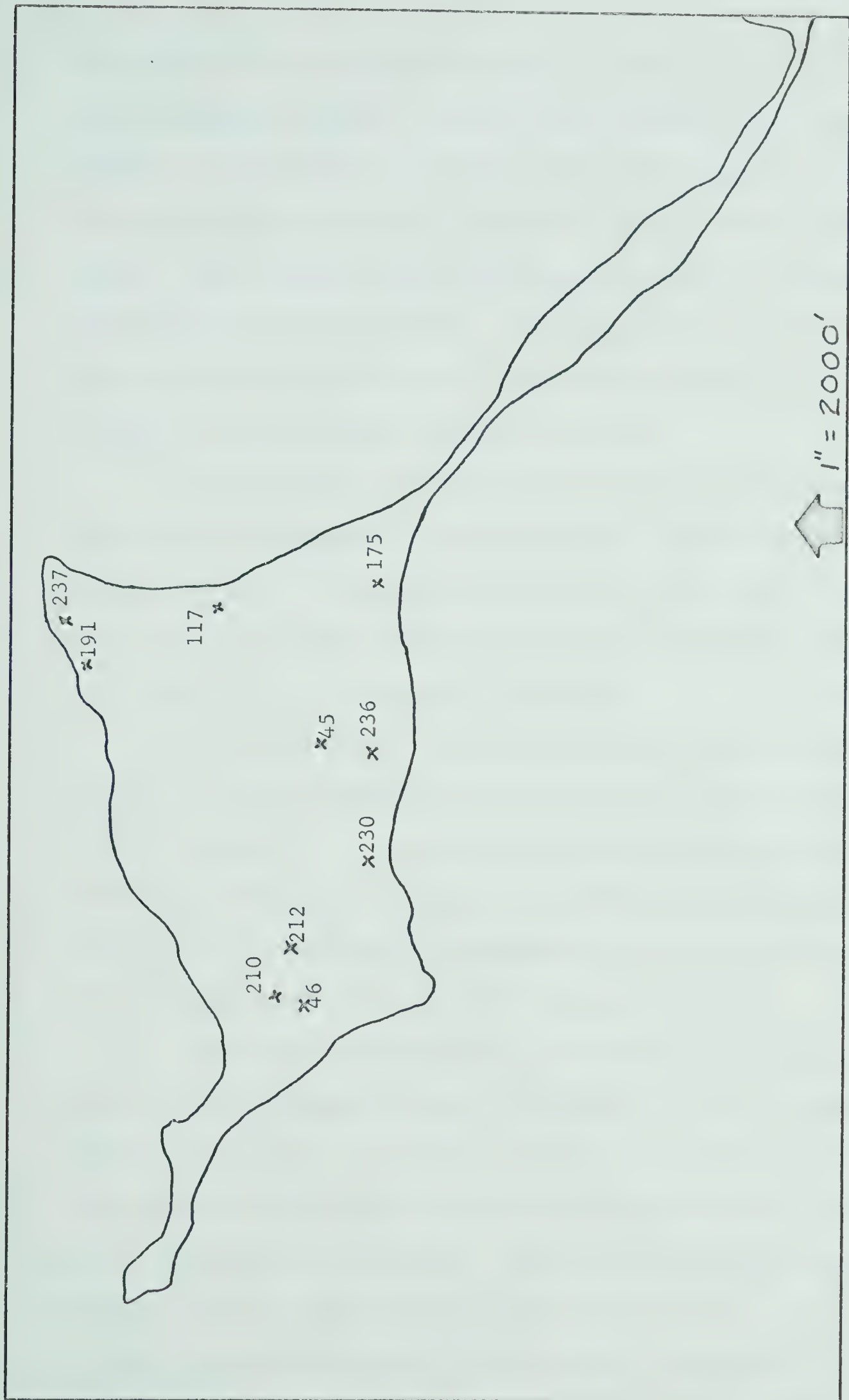


FIGURE 6. Locations of the Sampling Sites at Sir Winston Churchill Provincial Park



soil developed on the lacustrine material belongs to the Low Humic Eluviated Gleysol subgroup. One small area belonging to the Humic Eluviated Gleysol subgroup was found. The gleysols developed on the alluvial lacustrine material belong to the Rego Humic Gleysol subgroup. Their limited profile development indicates relatively recent deposition of the material. All the gleysols showed evidence of poor internal drainage (Appendix II Q-2 and II U-2, and frequently a surface organic horizon was present.

The Regosolic soils are found on coarse textured beach deposits and are restricted to the three major beach areas on the island. The lack of any profile development in these soils is indicative of the recent deposition of the beach deposits. These soils belong to the Orthic Regosol subgroup.

The Organic soils are found in the depressions on the island. The dominant Organic soils found belong to the Terric Fibrisol subgroup in the classification and are characterized by black spruce - sphagnum moss vegetation. The remaining Organic soils found are characterized by sedge vegetation and belong to the Terric Fibrisol, Mesisol, and Humisol subgroups.

The detailed morphological descriptions and analytical results for the two Grandin series (Orthic Gray Luvisol) profiles sampled are found in Appendix II L-2 and 3 and II M-2 and 3. These soils are characterized by a high base saturation and very strongly acid to mildly alkaline pH values. Calcium and magnesium are the dominant cations on the exchange complex of each horizon. Profile W.C. 236 (Appendix II L-3) has a very strongly to strongly acid



solum with the lowest value (4.7) in the Bt and BC horizons. Profile W.C. 175 (Appendix II M-3) is only slightly acid at the minimum. Morphologically this profile has indications of poor internal drainage. This could cause retardation of the leaching process and result in the less acid pH values found. The organic carbon content of the solum horizons is usually less than one per cent and the calcium carbonate equivalent of the Ck horizons is generally less than three per cent.

These soils show an accumulation of clay in the B horizons with clay content between 40 and 45 per cent. The clay content of the C horizons is approximately 35 per cent. The Ae horizons have the most variability in clay content. The Ae horizons in Profile W.C. 175 have a much lower clay content than the Ae horizon in Profile W.C. 236 (10 and 26 per cent, respectively). This may be explained by the topographical positions occupied by the profiles. Profile W.C. 236 was located on a slope while Profile W.C. 175 was located on a relatively flat area. Downward leaching on slope positions is generally less than on flat areas resulting in less downward movement of clay. Field observations showed that profiles on slope positions had thin Ae horizons relative to their counterparts on nearly level positions, further suggesting less downward leaching. The x-ray analysis (Appendix II L-5) of the clay fraction showed montmorillonite to be the dominant clay mineral present in these soils with lesser amounts of illite, kaolinite, and a trace of chlorite in the deep C horizon.

The Atterberg limits of these soils show a direct



relationship with clay content (Appendix II L-3). The liquid limit and plasticity index of the C horizons of these soils (approximately 35 and 20, respectively) are slightly higher than the C horizons of the Cooking Lake soils found at Miquelon Lake Provincial Park indicating the finer texture of the Grandin till relative to the Edmonton till.

The bulk density values of these soils are comparable to the till profiles previously discussed. The soil strength of the B and C horizons are significantly greater than the till profiles previously discussed indicating a more compact structure. Morphologically, the Grandin till appeared more compact than the Edmonton till.

The laboratory moisture analyses of these soils show a direct relationship to clay content within the profiles. The 1/3 bar and 15 bar moisture percentages, however, are lower (20 to 25 and 10 to 15 per-cent, respectively) than the Edmonton till profiles which are of slightly coarser texture. The natural moisture content appears to be quite stable during the year.

The detailed morphological descriptions and analytical results for the profiles developed on lacustrine material are found in Appendix II N-2 and 3, II O-2 and 3, and II P-2 and 3. These include the Maywood series (Orthic Gray Luvisol) in Appendix II N and II O and the Macola series (Dark Gray Luvisol) in Appendix II P. These soils are characterized by a high base saturation and extremely acid to neutral pH values. Calcium is the dominant cation found on the exchange complex of each horizon.



The pH values of the upper solum are medium acid (5.6 to 6.1) and decrease to extremely acid ( $\leq 4.6$ ) in the lower solum. The C horizons are near neutral (approximately seven). Luvisolic soils developed on lacustrine materials at Miquelon Lake Provincial Park are much less acid in reaction. The organic carbon contents of the upper horizons is generally less than one per cent except for the Ahe horizons which vary from approximately two per cent to greater than five per cent. The calcium carbonate equivalent of the C horizons is near one per cent.

The results of particle size analysis show an accumulation of clay in the B horizons with clay content ranging from 56 per cent in the upper B of profile W.C. 117 (Appendix II N-3) to 70 per cent in the upper B of profile W.C. 212 (Appendix II O-3). The higher clay content in the Ahe horizon of profile W.C. 212 and its relatively shallow depth are due to slope position (Appendix II O-1) as in the case of profile W.C. 236 (Appendix II L). The distribution of clay with depth below the solum in these soils was extremely variable, and in fact field observations showed stratification to be common in most profiles developed on lacustrine materials found on the island. X-ray analysis of the clay fraction (Appendix II N-5) showed montmorillonite to be the dominant clay mineral present.

The Atterberg limits of these soils are comparable to those reported for lacustrine profiles at Miquelon Lake Provincial Park and are significantly greater than values reported for the till profiles. The bulk density values are generally lower than



those found for the till profiles, the reason being the greater clay content in the lacustrine materials (Twardy, 1969).

The laboratory moisture analyses show a direct relationship to clay content. Within the profile the 1/3 bar and 15 bar moisture percentages increase with increases in clay content. The values reported for 1/3 bar moisture and 15 bar moisture are comparable to values reported for lacustrine materials found at Miquelon Lake Provincial Park. The natural moisture content of these soils was found to vary little during the year and in the lower horizons approached the lower limit of plant available moisture (15 bar moisture). The surface horizons were found to have natural moisture contents near the upper limit of plant available moisture (1/3 bar moisture).

The detailed morphological description and analytical results of the Snipe series (Low Humic Eluviated Gleysol developed on lacustrine material) profile sampled are presented in Appendix II Q-2 and 3. This soil is comparable to the Wildwood series found at Miquelon Lake Provincial Park (Appendix I H). The main differences between the two are the acid reaction (pH less than six), the organic surface deposit, and the lack of soluble salts in the Snipe soils. The results of physical analyses show no significant differences between the Snipe and Wildwood soils.

The detailed description and analytical results of the Culp series (Orthic Gray Luvisol developed on alluvial sand) profile sampled are presented in Appendix II R-2 and 3. These soils are characterized by a moderate to low base saturation and



very strongly to strongly acid pH values. The Culp soils on the island tend to have a more acid reaction than Culp soils found elsewhere (Bowser et al., 1962). The dominant cation on the exchange complex of each horizon is hydrogen (as high as 65 per cent in the B horizons). The pH values generally decrease with depth from 4.8 in the Ae horizon to 5.4 in the C horizon. The organic carbon content of the solum horizons, excluding the surface horizon, is generally less than one per cent and no free calcium carbonate occurs in the profile.

The particle size analysis shows a slight accumulation of clay in the B horizon which is enough to qualify these soils for the Luvisolic order. The grain size curve (Appendix II R-4) shows the sand material to be poorly graded. That is, most of the material is of one size fraction, and in this particular case 50 per cent of the material in the C horizon lies between the number 40 and number 60 sieve sizes.

Morphologically, these sandy soils have a loose single-grained structure, are non-plastic, and are rapidly drained. The slight accumulation of clay in the B horizons may offer some impedance to drainage and increase the water holding capacity a small amount. In fact, the lower limit of plant available moisture (15 bar moisture) in the upper solum (six per cent in upper B) is significantly greater than in the C horizons (one per cent).

The detailed morphological descriptions and analytical results of the Nestow and Edwand series (Degraded Dystric Brunisols) profiles sampled are presented in Appendix II S-2 and 3 and II T-2



3, respectively. The Nestow series is developed on alluvial sand and the Edwand series is developed on outwash deposits. These soils differ in that the outwash deposits have considerable amounts of coarse fragment (greater than two mm). Characteristically, these soils have a moderate base saturation (35 to 65 per cent) and strongly acid to neutral pH values. The dominant cations on the exchange complex of each horizon are hydrogen and calcium. The pH values generally increase with depth. The organic carbon content of the solum is generally less than one per cent with the exception of the Ahe horizons where it may approach two per cent. Free calcium carbonate is absent in the C horizons.

The particle size analysis shows the percentage of fines (Si plus C) to be considerably higher in the Ae horizons indicating active weathering and breakdown of the sandy parent materials. The grain size curve of the Nestow soil (Appendix II S-4) shows the parent material (C horizon) to be poorly graded as was the case for the Culp soil. On the other hand, the Edwand soil parent material is found to be fairly well graded (Appendix II T-4).

Morphologically, these soils have a loose single-grained structure, are non-plastic, and are rapidly drained. The higher percentage of fines in the surface horizons may slow the permeability and increase the water holding capacity; however, the lower limit of plant available water (15 bar moisture) is only twice that in the C horizons (four and two per cent, respectively).

The detailed morphological description and analytical results of the Lacroix series (Rego Humic Gleysol developed on



alluvial lacustrine material) profile sampled are presented in Appendix II U-2 and 3. These soils are characterized by a high base saturation and mildly to moderately alkaline pH values. Calcium is the dominant cation on the exchange complex of each horizon. The pH values range from 8.1 at the surface to 7.5 in the IIIC horizon. The organic carbon content of the surface horizon approximately 3.5 per cent and the calcium carbonate equivalent ranges from 0.5 per cent in the upper horizons to approximately two per cent in the lower horizons. There is a horizon of secondary lime accumulation at a depth of 70 to 95 cm. Frequently, these soils are calcareous to the surface.

Morphologically, these soils have indications of poor internal drainage (Appendix IIU-2) and little profile development indicating recent deposition of the material. Mottling is generally prominent throughout the profile and the matrix colors are very dull.

The particle size analysis shows these soils to have large amounts (58 per cent) of silt size (0.05 to 0.002 mm) particles in the alluvium portion of the profile. The lacustrine portion (IIC) and till portion (IIIC) of the profile are similar in particle size distribution to the lacustrine and till materials previously discussed.

The Atterberg limits found for the alluvium portion of the profile are lower than for the lacustrine and till portions which are similar to results discussed previously for the lacustrine and till materials. The natural moisture content of the alluvium



portion of the profile determined with bulk density is greater than the upper limit of plant available moisture (1/3 bar) and approaches the liquid limit.

### Soil Characteristics and Interpretations for Recreation Uses

Evaluations of soil characteristics for recreation were obtained from the detailed site descriptions and selected analytical data. Many soil properties affect the use limitations of soils for recreation, and the effects of a given soil property often vary with different uses. The degree of limitation assigned to a particular soil property was dependent on several factors. Generally, the four classes denoting limitations (Tables I to VII) were based on design or construction considerations including economy of operation. The soils were evaluated by considering the interaction of the properties to give an overall degree of limitation to each mapping unit. Soils with 'none to slight' limitations for recreation use are those in which the limitations can be easily overcome by correct planning, design, and management. Soils with 'severe' limitations include those in which careful planning and above-average design and management are likely to be uneconomical. Soils with 'moderate' limitations lie between the previous two classes. Normally the limitations of these soils can be overcome by suitable planning and management practices.

The soil properties affecting most recreational uses include wetness, susceptibility to flooding, slope gradient, and



TABLE I. Soil Limitations for Camping Areas

Soil Property Affecting Use	Degree of Soil Limitation			
	None	Slight	Moderate	Severe
Wetness	Very rapidly to well drained soils with water table below 3 feet during the use season	Moderately-well drained soils with water table below 3 feet during the use season	Moderately-well drained soils with water table less than 3 feet during the use season and imperfectly drained soils	Poorly and very poorly drained soils
Susceptibility to flooding	None	None	None	Subject to 1 or 2 floodings during use season.
Slope gradient	0 - 2%	2 - 9%	9 - 15%	>15%
Surface stoniness	Class 0	Class 1	Class 2	Classes 3, 4, 5
Permeability	Very rapid to moderately rapid	Moderate	Moderately slow	Slow and very slow
Surface soil texture	SL, FSL, VFSL Not subject to wind erosion	L and LS with a Bt horizon, not subject to wind erosion	CL, SCL, SiCL, SiL, LS and sand other than loose sand	Organic, C, HC, SiC, loose sand subject to severe wind erosion
Shrink-swell potential	Low	Medium	High	Very high
Trafficability	Surface bulk density greater than 1.2 g/cc	Surface bulk density between 1.0 to 1.2 g/cc	Surface bulk density between 1.0 and 0.8 g/cc	Surface bulk density less than 0.8 g/cc



TABLE II. Soil Limitations for Playground Areas

Soil Property Affecting Use	Degree of Soil Limitation			
	None	Slight	Moderate	Severe
Wetness	Very rapidly to well drained soils	Moderately-well drained soils	Imperfectly drained soils	Poorly and very poorly drained soils
Susceptibility to flooding	None during season of use	None during season of use	1 or 2 floodings during season of use	More than 2 floodings during season of use
Slope gradient	0%	0 - 2%	2 - 9%	>9%
Surface stoniness	Class 0	Class 1	Class 2	Classes 3, 4, 5
Permeability	Very rapid to moderately rapid	Moderate	Moderately slow	Slow and very slow
Surface soil texture	SL, FSL, VFSL	L and LS with a Bt horizon	CL, SCL, SiCL, SiL, LS, and S	SC, SiC, C, HC, organic, and sand subject to wind erosion
Shrink-swell potential	Low	Medium	High	Very high
Trafficability	Surface bulk density greater than 1.2 g/cc when underlying material is greater than 1.3 g/cc	Surface bulk density greater than 1.2 g/cc	Surface bulk density 1.0 to 1.2 g/cc	Surface bulk density less than 1.0 g/cc



TABLE III. Soil Limitations for Picnic Areas

Soil Property Affecting Use	Degree of Soil Limitation			
	None	Slight	Moderate	Severe
Wetness	Very rapidly to well drained soils	Moderately-well drained soils	Imperfectly drained soils	Poorly and very poorly drained soils
Susceptibility to flooding	None during season of use	None during season of use	1 or 2 floodings during season of use	More than 2 floodings during season of use
Slope gradient	0 - 2%	2 - 9%	9 - 15%	>15%
Surface stoniness	Class 0	Classes 1 and 2	Class 3	Classes 4 and 5
Permeability	Very rapid to moderately rapid	Moderate	Moderately slow	Slow and very slow
Surface soil texture	SL, FSL, VFSL, not subject to wind erosion	L and LS with a Bt horizon, not subject to wind erosion	CL, SCL, SiCL, SiL, SC, SiC, C, LS, and sand other than loose sand	Organic, sand, and soils subject to severe wind erosion
Shrink-swell potential	Low	Medium	High	Very high
Trafficability	Surface bulk density greater than 1.2 g/cc when underlying material is greater than 1.3 g/cc	Surface bulk density between 1.0 and 1.2 g/cc	Surface bulk density between 0.8 and 1.0 g/cc	Surface bulk density less than 0.8 g/cc



TABLE IV. Soil Limitations for Hiking Trails

Soil Property Affecting Use	Degree of Soil Limitation			
	None	Slight	Moderate	Severe
Wetness	Well drained soils with water table below 3 feet	Moderately-well drained soils with water table below 3 feet	Imperfectly drained soils with water table 1 to 3 feet	Poorly drained and very poorly drained soils
Susceptibility to flooding	None during season of use	None during season of use	1 or 2 floodings during season of use	More than 2 floodings during season of use
Slope gradient	0 - 9%	9 - 15%	15 - 30%	>30%
Surface stoniness	Class 0	Classes 1 and 2	Class 3	Classes 4 and 5
Surface soil texture	SL, FSL, and VFSL	L	SiL, SiCL, SCL, CL, SC, SiC, C, and LS	Sand, organic soils, subject to severe wind erosion
Trafficability	Surface bulk density greater than 1.2 g/cc when underlying material is greater than 1.3 g/cc	Surface bulk density greater than 1.2 g/cc	Surface bulk density 1.0 to 1.2 g/cc	Surface bulk density less than 1.0 g/cc



TABLE V. Soil Limitations for Permanent Buildings\*

Soil Property Affecting Use	Degree of Soil Limitation			
	None	Slight	Moderate	Severe
Wetness	Well drained soils over 4 feet to water table	Moderately-well drained soils	Imperfectly drained soils, water table 2 to 4 feet	Poorly and very poorly drained soils
Susceptibility to flooding	None	None	None	Subject to flooding at some time
Slope gradient	0 - 2%	2 - 9%	9 - 15%	>15%
Surface stoniness	Class 0	Class 1	Class 2	Classes 3, 4, 5
Shrink-swell potential	Low	Medium	High	Very high
Sulphate attack on concrete	Soluble sulphate content between 0 and 0.1%	Soluble sulphate content between 0.1 and 0.2%	Soluble sulphate content between 0.2 and 0.5%	Soluble sulphate content greater than 0.5%

\* Applies to buildings with basement or slab foundations.



TABLE VI. Soil Limitations for Road Location and Source of Subgrade Material

Soil Property Affecting Use	Degree of Soil Limitation			
	None	Slight	Moderate	Severe
Wetness*	Well drained soils	Moderately-well drained soils	Imperfectly drained soils	Rapidly drained and poorly and very poorly drained soils
Susceptibility to flooding*	None during season of use	None during season of use	None during season of use	Subject to flooding during season of use
Slope gradient*	0 - 2%	2 - 9%	9 - 15%	>15%
Surface stoniness***	Class 0	Class 1	Class 2	Classes 3, 4, 5
Shrink-swell potential**	Low	Medium	High	Very high
Permeability*	Moderately rapid	Moderate	Moderately slow	Very rapid and rapid, slow and very slow
Unified rating**	CL, CL-ML	CL-ML	CL-CH, ML	CH, MH
Workability**	Soils with liquidity index between 0 and 1	Soils with liquidity index between 0 and 1	Soils with liquidity index less than 0	Soils with liquidity index greater than 1

\* Applies to road location.

\*\* Applies to suitability of C horizon as a source of subgrade material.

\*\*\* Applies to both road location and suitability as a source of subgrade material.



TABLE VII. Soil Limitations for Sewage Disposal

Soil Property Affecting Use	Degree of Soil Limitation			
	None	Slight	Moderate	Severe
Wetness	Well drained soils	Moderately-well drained soils	Imperfectly drained soils	Rapidly drained soils and poorly and very poorly drained soils
Susceptibility to flooding	None during season of use	None during season of use	None during season of use	Subject to flooding 1 or more times during season of use
Slope gradient	0%	0 - 2%	2 - 9%	>9%
Permeability	Moderate	Moderate	Moderately rapid, moderately slow	Very rapid and rapid, very slow and slow



surface stoniness (Montgomery and Edminster, 1966). Other soil properties selected include depth to an impeding horizon and surface soil texture for permeability, erodibility, and vegetation stability inferences; Atterberg limits for shrink-swell potential inferences; bulk density\* and plasticity for trafficability inferences; natural moisture content and Atterberg limits for certain construction inferences such as workability of the underlying material for road subgrade purposes; and soluble sulphate content of the underlying soil material for concrete corrosion inferences.

Wetness is a soil property that affects all recreation activities. Soils that are wet throughout the season of use have characteristics of poor internal drainage and include the poorly and very poorly drained drainage classes outlined by the N.S.S.C. (1968). These soils are considered to have severe limitations for all the common recreation facilities. The economic feasibility of installing subsurface drainage in these soils is questionable. Soils that are wet for only a portion of the season of use and the soils with a fluctuating water table that never reaches the surface are considered to have moderate limitations for recreation use. The imperfectly and moderately-well drained drainage classes outlined by the N.S.S.C. are included. With careful planning, design, and management these soils can be used for most recreation facilities; however, if possible they should be avoided for the more permanent

\* Bulk density is equivalent to 'Total Unit Weight' in soil engineering practice.



facilities such as camping areas, playground areas, and building sites. The soils that are dry during the season of use and have a water table greater than three feet from the surface are considered to have slight to no limitations for recreation use. The moderately-well drained soils have slight limitations and the well to rapidly drained soils have no limitations.

Soils that are subject to flooding during the season of use are considered to have severe limitations for recreation facilities requiring permanent design considerations (camping areas, building sites, and roads). These soils would require flood protection structures which may be uneconomical. These soils should be developed for the less permanent facilities. Montgomery and Edminster (1966) suggest one or two floodings during the season of use constitutes only a moderate limitation for picnic areas, playground areas, and hiking trails. These facilities can be moved with relative ease. Thus, these soils can be managed to a high level without maintenance costs rising beyond the financial capacity of the administration.

Slope gradient affects the use of soils for recreation. Generally, slopes of less than two per cent offer no limitation. Slopes greater than nine per cent constitute a severe limitation for playground areas since levelling costs would become prohibitive. Slopes greater than 15 per cent constitute a severe limitation for camping areas, picnic areas, and some building sites for the same reason. The smaller area required for these facilities relative to playground areas is considered responsible for the greater



tolerance. Hiking trails are not limited until slopes become greater than 30 per cent.

Surface stoniness limits the use of some soils for recreation facilities. Generally, the non-stony (class 0) to slightly stony (class 1) land as defined by the N.S.S.C. (1968) offers no limitation for recreation facilities. Very stony (class 3) to excessively stony (class 5) land offers severe limitations for camping areas, playground areas, building sites, and road subgrade material. The expense of removing the stone hazard is considered prohibitive. The very stony (class 3) land is considered to constitute only a moderate limitation for picnic areas and hiking trails because of the lesser areal intensity of use associated with these facilities.

Permeability is an important property affecting the recreation use of soils. Since no permeability measurements were made it has been assessed from a consideration of texture, structure, and depth to the impeding horizon in the profile. The soils were given a permeability rating according to the classes defined by O'Neal (1952). Soils with very rapid to moderately rapid permeability have no limitations and soils with slow and very slow permeability have severe limitations as outlined by Montgomery and Edminster (1966). The same classes apply to suitability for road subgrade material. It should be noted that the degree of limitation due to permeability will vary with climate. In high rainfall areas permeability is much more important than in low rainfall areas. Since there were no



precipitation and storm intensity records available for the study areas, it was considered that the annual precipitation was less than in the areas where Montgomery and Edminster established their groupings. Thus, permeability was assigned a subordinate role in determining the overall ratings for the mapping units.

Surface soil texture is also an important soil property to consider. High clay or sand content in the surface horizon constitutes a severe limitation for camping and playground areas. Soils high in clay become sticky when wet and dry out slowly after rains. On the other hand, sandy soils are unstable when dry making it difficult to establish sod grasses capable of withstanding concentrated human traffic. Generally, sandy loam to loam surface soil textures are most desirable for recreation purposes.

Shrink-swell potential was inferred from the Atterberg limits and the plasticity chart devised by Casagrande (1932). Soils with low to medium shrink-swell potential are considered to have none to slight limitations for recreation facilities. Soils with a very high shrink-swell potential are considered to constitute severe limitations for use. These soils would require thicker gravel pads for camping areas and thus raise the cost of development. Generally, these soils are unsuitable for road subgrade material as they tend to be unstable with changing moisture conditions. Soils with a high shrink-swell potential offer moderate limitations for use and thus should be avoided if possible.



Trafficability was inferred from bulk density of the surface relative to the underlying material. Soils with surface bulk density nearly equal to that of the underlying material are considered to have no limitations for recreation use providing the bulk density of the underlying material is greater than 1.3 g/cc. Soils with surface bulk density values much lower than the underlying material are susceptible to compaction and are considered to have severe limitations for recreation facilities. Soils included in the group generally have Ah and Ahe horizons with bulk densities less than one and underlying materials with bulk densities greater than 1.3. These soils should be avoided because of possible long term damage to the resource base. Also, these soils are generally more susceptible to trampling and erosion by either wind or water.

The suitability of the underlying soil material for road subgrade depends on several additional properties. Workability of the underlying material was considered. Workability is considered to offer none to slight limitations for road subgrade purposes when the liquidity index is between zero and one. Liquidity index is calculated from the Atterberg limits and natural moisture content (Terzaghi and Peck, 1967). Soils with moderate limitations have a liquidity index of less than zero which means these soils are too dry to be remolded. Soils with severe limitations have a liquidity index of greater than one which means these soils have a moisture content such that they tend to fail when remolded. The Unified rating was also considered useful for evaluating the



soils for subgrade materials. Generally, soils with CL and CL-ML ratings are considered to have no limitations and the soils with CH, MH, and ML ratings are considered to have severe limitations. The soils intermediate between CL and CH are considered to have moderate limitations for road subgrades. Susceptibility to frost action is also an important consideration in selecting soils as a source of subgrade material. Generally, soils high in silt content are highly susceptible to frost action. Other factors affect frost action as well and one is the availability of water. This involves climatic considerations and depth to water table measurements which are not available. Thus the susceptibility to frost action was not used in establishing soil limitation classes for subgrade material.

Sewage disposal is also an important consideration in designing recreation areas. Generally, soils that are slowly or rapidly permeable, poorly drained, subject to flooding, or steeply sloping have severe limitations for sewage disposal (Montgomery and Edminster, 1966). These include the soils high in clay content, the sandy soils, and the Gleysolic soils. The most desirable soils for sewage disposal have a moderate permeability, are well drained, and are situated on nearly level surfaces.

The soluble sulphate content of the underlying soil material is an important factor for buildings with a concrete foundation. The U. S. Bureau of Reclamation\* has established

\* U.S.D.I. Bureau of Reclamation. 1966. Concrete Manual.  
U.S. Government Printing Office, Washington.



classes for sulphate attack on concrete. Soils with zero to 0.1 per cent soluble sulphate content are considered to have no limitations for standard concrete foundations and soils with 0.1 to 0.2 per cent are considered to have slight limitations. Soils with 0.2 to 0.5 per cent soluble sulphate content are considered to have moderate limitations and foundations may require sulphate resistant concrete. Soils with greater than 0.5 per cent soluble sulphate are considered to have severe limitations and should be avoided.

The properties used and their limitations for each of the recreation facilities considered are presented in Tables I to VII. These guides were then used as a "key" to evaluate the mapping units for each particular facility.

#### Miquelon Lake Provincial Park.

The recreation use characteristics of the soils at Miquelon Lake Provincial Park are shown in Tables VIII, IX, and X. The evaluation of the characteristics for each mapping unit and each of the recreation facilities considered is shown in Table XI. The enclosed maps show the distribution of the soil limitation groupings. The groupings are shown as numbers where 1 represents soils with no limitations, 2 represents soils with slight limitations, 3 represents soils with slight to moderate limitations, 4 represents soils with moderate limitations, 5 represents soils with moderate to severe limitations, and 6 represents soils with severe limitations.



The soil characteristics for recreation use of the till profiles at Miquelon Lake Provincial Park are listed in Table VIII. The Luvisolic soils in the upper portion of the toposequence described previously (page 37) have no internal drainage or flooding limitations for any of the recreation uses considered. These soils include the Cooking Lake, Uncas, and Falun series. The Egremont soils found on lower slope positions have moderate drainage limitations and they generally are not subject to flooding during the season of use. The Gleysolic soils (Onoway, Mapova, and Demay series) have severe internal drainage limitations for all recreation uses and they may be subject to more than one flooding during the season of use.

The upland till profiles (Cooking Lake, Uncas, and Falun series) have slight to severe slope limitations for all recreation uses except hiking trails. The lowland profiles (Gleysolic soils) generally have no slope limitations.

The till profiles are generally considered to have slight to moderate surface stoniness limitations with the exception of the coarse Cooking Lake phase which has moderate to severe limitations. Permeability limitations are considered to be moderate to severe for camping areas, playground areas, picnic areas, source of subgrade material, and sewage disposal on all these soils except the coarse Cooking Lake phase. This soil is considered to have moderate permeability limitations for all uses except sewage disposal where it is considered to have slight to moderate limitations.

The surface soil texture and bulk density of the Cooking



TABLE VIII

(See over)

TABLE VIII. The Soil Characteristics for Recreation Use of the Till Profiles at Miquelon Lake Provincial Park

Soil Series	Wetness	Flooding	Slope Gradient %	Surface Stoniness	Permeability	Surface Soil Texture
Cooking Lake	Mod.-well drained	None	5-30	S2	Slow	L
Coarse Cooking Lake	Well drained	None	5-30	S3	Mod. slow	SL
Uncas	Mod.-well drained	None	5- 9	S2	Slow	L
Falun	Well drained	None	2- 5	S2	Slow	L
Egremont	Imperfectly drained	None	2- 9	S2	Slow	L
Onoway	Poorly drained	Subject to 1 or more floodings during season of use	0- 5	S1	Slow	L-CL
Mapova	Poorly drained	Subject to 1 or more floodings during season of use	0- 5	S1	Slow	L-CL
Demay	Poorly drained	Subject to 1 or more floodings during season of use	0- 5	S1	Slow	L-SiL

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Shrink-Swell Potential		Bulk Density g/cc		Liquidity Index	Unified Rating	Soluble Sulphate %
B Hor.	C Hor.	Surface	C Hor.	C Hor.	C Hor.	C Hor.
Med.	Med.	1.35- 1.43	1.70	0.3	CL	0.11- 0.17
Low	Low	1.45	1.70	-0.1- -0.3	SC	Trace
Low- Med.	Low	0.50	1.70	0.3	SC	0.02
--	--	--	--	--	--	--
--	--	--	--	--	--	--
Med.	Med.	0.86	1.70	0.1	CL	0.13- 0.18
--	--	--	--	--	--	--
--	--	--	--	--	--	--

---



Lake soils indicate these soils have none to slight limitations for the recreation facilities considered. The soils with Ah and Ahe horizons (Uncas, Falun, Egremont, and Onoway series) greater than five centimetres have low surface bulk densities and are considered to have severe trafficability limitations for camping areas, picnic areas, playground areas, and hiking trails. The surface texture of the Gleysolic soils indicates slight to moderate limitations for use.

The B and C horizons of the till profiles have a low to medium shrink-swell potential and are considered to offer slight limitations for use. Generally, the natural moisture content of these soils is favorable and enables use of the C horizon material as a source of road subgrade. The coarse Cooking Lake phase is the exception. The natural moisture content in the C horizon of this soil is generally low (negative liquidity index) indicating these soils cannot be remolded in their present state. The soluble sulphate content of the C horizon material of the Cooking Lake soils is generally between 0.1 and 0.2 per cent indicating these soils have slight limitations for using standard concrete in foundations of buildings.

The soil characteristics for recreation use of the lacustrine profiles at Miquelon Lake Provincial Park are listed in Table IX. The Luvisolic and Solonetzic soils (Maywood, Monique, and Tawayik series) have slight to moderate internal drainage limitations for the recreation facilities considered, and are not susceptible to flooding at any time during the season of use. The Gleysolic



TABLE IX

(See over)

TABLE IX. The Soil Characteristics for Recreation Use of the Lacustrine Profiles at Miquelon Lake Provincial Park

Soil Series	Wetness	Flooding	Slope Gradient %	Surface Stoniness	Permeability	Surface Soil Texture
Maywood	Imperfectly to mod.-well drained	None	5-9	S0	Slow to very slow	SiL-SiCL
Monique	Imperfectly to mod.-well drained	None	2-9	S0	Slow to very slow	SiCL
Tawayik	Imperfectly to mod.-well drained	None	2-5	S0	Slow to very slow	SiCL
Raven	Poorly drained	Subject to 1 or more floodings during season of use	0-5	S0	Slow to very slow	SiC
Denville	Poorly drained	Subject to 1 or more floodings during season of use	0-5	S0	Slow to very slow	SiCL
Wildwood	Poorly drained	Subject to 1 or more floodings during season of use	0-5	S0	Slow to very slow	SiCL-SiC
Boag	Poorly drained	Subject to 1 or more floodings during season of use	0-2	S0	Slow to very slow	SiC
Bittern	Poorly drained	Subject to 1 or more floodings during season of use	0-2	S0	Slow to	SiC

Shrink-Swell Potential		Bulk Density g/cc		Liquidity Index	Unified Rating	Soluble Sulphate %
B Hor.	C Hor.	Surface	C Hor.	C Hor.	C Hor.	C Hor.
--	--	--	--	--	--	--
High	Med.	1.38	1.40	0.1	CL	0.12- 0.27
--	--	--	--	--	--	--
Med.	High	0.86	1.50	--	CL	0.13- 0.17
--	--	--	--	--	--	--
Med.	Med.	1.05	1.40	--	CL	0.26- 0.43
--	--	--	--	--	--	--
--	--	--	--	--	--	--



soils have severe internal drainage limitations and may be susceptible to one or more floodings during the season of use. These soils have moderate slope limitations only for playground areas and sewage disposal. Surface stoniness is no problem.

Permeability limitations of these soils are severe and the surface texture limitations are moderate to severe. Due to their high clay content which is predominantly montmorillonitic, the shrink-swell potential of these soils is medium to high. These soils have moderate shrink-swell limitations for use. In the soils with thin ( $< 90$  cm) lacustrine profiles the underlying till material is considered accessible as a source of road subgrade and these soils are rated as having slight limitations as a source of road subgrade. These soils are the Monique and Tawayik series. The surface bulk density of these soils indicates slight trafficability limitations for use. This does not hold true for the Tawayik soils which have Ah horizons greater than five centimetres thick.

Generally, the natural moisture content in these soils is favorable and enables the IIC horizon material to be used as a source of road subgrade. The Unified rating of the IIC horizon material supports the above statement. At some time during the year the natural moisture content of the Gleysolic soils may become very high resulting in a liquidity index greater than one. This indicates these soils will fail to a "slurry" when remolded and thus have severe limitations as a source of road subgrade. The soluble sulphate content in the C and IIC horizons of these soils often exceeds 0.2 per cent indicating these soils may be corrosive to



TABLE X

(See over)

TABLE X.     The Soil Characteristics for Recreation Use of the Beach  
                 Deposit Profiles at Miquelon Lake Provincial Park

Soil Series	Wetness	Flooding	Slope Gradient %	Surface Stoniness	Perm-eability	Surface Soil Texture
Wanisan (2)	Poorly drained	Subject to 1 or more floodings during season of use	2-5	S0-S5	Mod. slow	Coarse, med., and fine sand
(3)	Poorly drained	Subject to 1 or more floodings during season of use	0-5	S0	Mod.	Coarse, med., and fine sand
(4)	Poorly drained	None	0-5	S0	Rapid	Coarse, med., and fine sand
(5)	Imperfectly drained	None	0-5	S0	Rapid	Coarse, med., and fine sand
Lindbrook	Rapidly drained	None	0-5	S0	Very rapid	Fine and med. gravel
Coarse Lindbrook	Rapidly drained	None	0-5	S0	Very rapid	Coarse gravel and cobbles

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Shrink-Swell Potential		Bulk Density g/cc		Liquidity Index	Unified Rating	Soluble Sulphate %
B Hor.	C Hor.	Surface	C Hor.	C Hor.	C Hor.	C Hor.
Very high in Lac- ustrine portion med. in till portion		--	--	--	CL	0.12- 0.20
Med. in till till portion		--	--	--	CL	0.10- 0.23
--	--	--	--	--	--	--
--	--	--	--	--	--	--
--	--	--	--	--	--	--
--	--	--	--	--	--	--

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standard concrete foundations.

The soil characteristics for recreation use of the beach deposit profiles (Wanisan and Lindbrook series) at Miquelon Lake Provincial Park are listed in Table X. The Gleysolic soils (Wanisan series) have moderate to severe drainage limitations for recreation use. The deepest phase (W<sub>1</sub>5) of this series may have slight to moderate limitations. The Regosolic soils (Lindbrook series) have no drainage limitations. The two shallow phases (W<sub>1</sub>2 and W<sub>1</sub>3) of the Wanisan series may be susceptible to flooding during the season of use. The remaining beach deposit soils are not susceptible to flooding. There are no slope limitations on these soils. Surface stoniness is a severe limitation in the Wanisan 2 and coarse Lindbrook phases.

The permeability limitations of these soils are moderate in the Wanisan 2 phase and only slight in the other Wanisan phases. Surface texture limitations are moderate to severe. These soils are not subject to shrink-swell problems except in the shallow phases of the Wanisan series. In these cases the same limitations that were discussed for the till and lacustrine profiles apply.

The natural moisture content of the underlying till and lacustrine material associated with the Wanisan soils may reach a level high enough to result in a liquidity index greater than one. Thus, these soils should be avoided for a source of road subgrade even though the Unified rating suggests the underlying till material has no limitations for use. The soluble sulphate content of the underlying till material frequently exceeds 0.2 per cent indicating



TABLE XI. The Degree of Limitation\* of the Soils at Miquelon Lake  
Provincial Park for Recreation Use

Mapping Unit	Camping Areas	Playground Areas	Picnic Areas	Hiking Trails	Permanent Buildings	Road Loc- ation and Subgrade Source	Sewage Disposal
Cooking Lake							
III	4	4	2	1	2	3	4
IV	5	6	4	2	4	4	5
V	6	6	6	4	6	6	6
Cooking Lake coarse phase							
III	5	6	4	2	4	5	3
IV	6	6	4	2	6	5	5
V	6	6	5	4	6	6	6
Uncas							
III	4	4	4	6	2	3	4
Falun							
II	2	4	4	6	2	3	4
Egremont							
II	4	4	4	6	4	4	5
III	4	5	4	6	4	4	5
Onoway							
I and II	6	6	6	6	6	6	6
Mapova							
II	6	6	6	6	6	6	6
Demay							
II	6	6	6	6	6	6	6
Maywood							
III	4	4	4	2	2	6	5
Monique							
II	4	4	4	4	4	3	4
III	4	5	4	4	2	3	4
Tawayik							
II	4	5	4	4	2	3	4
Raven							
I and II	6	6	6	6	6	6	6



TABLE XI. (Continued)

Mapping Unit	Camping Areas	Playground Areas	Picnic Areas	Hiking Trails	Permanent Buildings	Road Loc- ation and Subgrade Source	Sewage Disposal
Denville I and II	6	6	6	6	6	6	6
Westwind I and II	6	6	6	6	6	6	6
Boag I	6	6	6	6	6	6	6
Bittern I	6	6	6	6	6	6	6
Wanisan 2	6	6	6	6	6	6	6
Wanisan 2 stony phase	6	6	6	6	6	6	6
Wanisan 3	6	6	6	6	6	4	6
Wanisan 4	5	5	4	5	5	4	6
Wanisan 5	4	4	4	5	5	4	6
Lindbrook	1	1	1	1	1	4	6
Lindbrook coarse phase	6	6	5	5	6	1	6

- \* 1 - no limitations  
 2 - slight limitations  
 3 - slight to mod. limitations  
 4 - mod. limitations  
 5 - mod. to severe limitations  
 6 - severe limitations



these soils may be corrosive to standard concrete foundations.

Sir Winston Churchill Provincial Park.

The characteristics for recreation use of the soils at Sir Winston Churchill Provincial Park are shown in Tables XII, XIII, XIV, and XV. The evaluation of the characteristics for each mapping unit and each of the recreation facilities considered is shown in Table XVI. The enclosed maps show the distribution of the soil limitation groupings. As for Miquelon Lake Provincial Park, the groupings are represented by numbers.

The soil characteristics for recreation use of the till profiles in the park are listed in Table XII. These soils (Luvisolic) have slight to moderate internal drainage limitations and are not subject to flooding during the season of use. The Lac La Biche soils may be subject to one or two floodings during the season of use. Slope limitations of these soils are severe only for picnic areas and sewage disposal. The level areas tend to be depressional and are considered to have moderate slope limitations for this reason. Surface stoniness is generally not a problem. The soils on the Grandin till have severe permeability limitations and the soils on the Athabasca till have moderate permeability limitations. Surface texture is generally not a limitation.

The bulk density of the surface horizons in these soils is lower than the underlying till. Thus, these soils are subject to compaction under heavy use and are considered to have moderate limitations for use. The soils with Ah and Ahe horizons greater



TABLE XII

(See over)

TABLE XII.    The Soil Characteristics for Recreation Use of the Till  
                 Profiles at Sir Winston Churchill Provincial Park

Soil Series	Wetness	Flooding	Slope Gradient %	Surface Stoniness	Perm-eability	Surface Soil Texture
Grandin	Mod.-well to imperfectly drained	None	0-15	S1	Slow	SiL-SL
Winston	Mod.-well drained	None	0-15	S1	Slow	L
Lac La Biche	Imperfectly drained	None	2- 5	S1	Slow	L
Athabasca	Mod.-well drained	None	2-15	S2	Mod. slow	L-SL
Grosmont	Mod.-well drained	None	5- 9	S2	Mod. slow	L

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Shrink-Swell Potential		Bulk Density g/cc		Liquidity Index	Unified Rating
B Hor.	C Hor.	Surface	C Hor.	C Hor.	C Hor.
Med.	Med.	1.10	1.70	0.4	CL
--	--	--	--	--	--
--	--	--	--	--	--
--	--	--	--	--	--
--	--	--	--	--	--

---



than five centimetres in thickness (Winston, Lac La Biche, and Grosmont series) are likely to have lower surface bulk densities than the Orthic Gray Luvisols (Grandin and Athabasca series) and thus be more susceptible to compaction. These soils are considered to have moderate to severe trafficability limitations. The shrink-swell potential of the B and C horizon material of these soils is medium and constitutes only slight limitations for use.

The natural moisture content in the C horizon of these soils is generally favorable and enables use of the material as a source for road subgrade. The Unified rating further supports the above statement. The soluble sulphate content of the C horizon material was considered to be negligible.

The soil characteristics for recreation use of the lacustrine profiles in the park are listed in Table XIII. The Luvisolic soils (Maywood, Miquelon, Macola, Tawayik, and Red Fox series) have slight to moderate internal drainage limitations and are not subject to flooding during the season of use. The Red Fox soils may be subject to one or more floodings during the season of use. The Gleysolic soils (Snipe and Sawdy series) have severe internal drainage limitations and may be subject to one or more floodings during the season of use.

The Luvisolic soils have from none to severe slope limitations for use and the Gleysolic soils, generally found in depressional areas, have no slope limitations. Surface stoniness is not a problem in these soils. These soils are considered to have severe permeability limitations and the surface texture offers moderate limitations for use.



TABLE XIII

(See over)

TABLE XIII. The Soil Characteristics for Recreation Use of the Lacustrine Profiles at Sir Winston Churchill Provincial Park

Soil Series	Wetness	Flooding	Slope Gradient %	Surface Stoniness	Perm-eability	Surface Soil Texture
Maywood	Imperfectly to mod.-well drained	None	2-30	S0	Slow	SiL-SiCL
Miquelon	Imperfectly to mod.-well drained	None	2-15	S0	Slow	SiL-SiCL
Macola	Imperfectly to mod.-well drained	None	2-15	S0	Slow	SiL-L
Tawayik	Imperfectly to mod.-well drained	None	2- 9	S0	Slow	SiL-L
Red Fox	Imperfectly drained	Subject to 1 or more floodings during season of use	0- 2	S0	Slow	SiL-L
Snipe	Poorly drained	Subject to 1 or more floodings during season of use	0- 2	S0	Slow	SiL
Sawdy	Poorly drained	Subject to 1 or more floodings during season of use	0- 2	S0	Slow	SiL

Shrink-Swell Potential		Bulk Density g/cc		Liquidity Index	Unified Rating
B Hor.	C Hor.	Surface	C Hor.	C Hor.	C Hor.
High	--	1.2	1.4	-0.3	CL-CH
--	--	--	--	--	--
High to very high	Very	1.2	1.4	-0.1	CH
--	--	--	--	--	--
--	--	--	--	--	--
High	--	--	--	--	CL-CH
--	--	--	--	--	--



The surface bulk density of these soils indicates these soils are not subject to compaction under heavy use. These soils are considered to have no limitation for trafficability. The soils with Ah horizons greater than five centimetres thick would have lower surface bulk densities and thus are subject to compaction. These soils are considered to have moderate trafficability limitations for use.

The shrink-swell potential of the B and C horizon material of these soils is high to very high indicating moderate to severe limitations for use. The natural moisture content in the C horizons of these soils is generally unfavorable. The negative liquidity index indicates moisture requirements for remolding. When this is combined with the high shrink-swell potential, these soils are not favorable as a source of road subgrade. In the soils with thin ( $\leq 90$  cm) lacustrine profiles the underlying till may be used as a source of road subgrade. All the lacustrine profiles are considered to have moderate shrink-swell limitations for uses not requiring disturbance of the soil. Soluble sulphate content of the C horizon material was considered to constitute no limitations to standard concrete foundations.

The soil characteristics for recreation use of the alluvial-lacustrine profiles in the park are listed in Table XIV. These soils are found in depressional areas and surface drainage channels. As a result these soils usually have severe internal drainage limitations and may be susceptible to one or more floodings during the season of use. In most cases these soils are Gleysolics. However, the Rich



TABLE XIV

(See over)

TABLE XIV.    The Soil Characteristics for Recreation Use of the Alluvial-Lacustrine Profiles at Sir Winston Churchill Provincial Park

Soil Series	Wetness	Flooding	Slope Gradient %	Surface Stoniness	Perm-eability	Surface Soil Texture
Rich Lake	Imperfectly drained	None	0-2	S0	Mod.	SiL
Wanham	Poorly to very poorly	Subject to 1 or more floodings during season of use	0-2	S0	Mod. slow	SiL
Lacroix	Poorly drained	Subject to 1 or more floodings during season of use	2-5	S0	Mod. slow	L-SL

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Shrink-Swell Potential		Bulk Density g/cc		Liquidity Index	Unified Rating
B Hor.	C Hor.	Surface	C Hor.	C Hor.	C Hor.
--	--	--	--	--	--
--	--	--	--	--	--
Low in C		1.24	1.40	0	CL-ML
High in IIC		--	1.40	--	CL
Med. in IIIC		--	1.70	--	CL

---



Lake soils were considered to have slightly better drainage qualities than most soils found on the alluvial-lacustrine material. These soils have no slope or surface stoniness limitations, and moderate permeability and surface texture limitations.

The shrink-swell potential is low in the alluvium portion of the profile, high in the lacustrine portion, and medium in the till portion. These soils are considered to have moderate shrink-swell limitations for all recreation activities not requiring disturbance of the profile. The surface bulk density indicates these soils are relatively compact and thus have no trafficability limitations.

The natural moisture content in relation to the Atterberg limits in the alluvium portion of the Lacroix soils may be great enough to give a liquidity index greater than one indicating these soils may fail when remolded. Thus, these soils are considered to have severe limitations for locating permanent buildings. The Unified rating indicates the underlying till material is a suitable source for road subgrade. The soluble sulphate content of the underlying material in these soils was considered to be negligible.

The soil characteristics for recreation use of the coarse textured profiles in the park are listed in Table XV. These soils have no internal drainage limitations for any of the recreation facilities considered except sewage disposal and location of roads. Other than the Medley soils, these soils are not susceptible to flooding during the season of use. Permeability was considered to be a severe limitation for road subgrade and sewage disposal.



TABLE XV

(See over)

TABLE XV. The Soil Characteristics for Recreation Use of the Coarse Textured Profiles at Sir Winston Churchill Provincial Park

Soil Series	Wetness	Flooding	Slope Gradient %	Surface Stoniness	Permeability	Surface Soil Texture
Culp	Well to rapidly drained	None	5-30+	S0	Rapid	LS
Nestow	Rapidly drained	None	2-30+	S0	Very rapid	LS
Edwand	Rapidly drained	None	0- 9	S3	Very rapid	SL-LS
Downing	Rapidly drained	None	0- 9	S3	Very rapid	SL-LS
Medley	Rapidly drained	Subject to 1 or more floodings during season of use	0- 5	S0	Very rapid	Coarse sand

---

Shrink-Swell Potential		Bulk Density g/cc		Liquidity Index	Unified Rating
B Hor.	C Hor.	Surface	C Hor.	C Hor.	C Hor.
--	--	--	--	--	SP
--	--	--	--	--	SP
--	--	--	--	--	SW-SM
--	--	--	--	--	--
--	--	--	--	--	--

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Generally, shrink-swell potential and surface texture of these soils constitute no limitation for use.

The Culp and Nestow soils have slight to severe slope limitations and the others have slight to moderate slope limitations. Surface stoniness constitutes a severe limitation in the Edwand and Downing soils for all uses except picnic areas and hiking trails.

The natural moisture content of these soils is generally low due to their low moisture holding capacity. As a result these soils were considered to be unsuitable as a source of road subgrade. The Unified rating indicates the C horizon material of the Edwand soils is well graded and thus may be used as a source of gravel for road surfacing. The soluble sulphate content of these soils was considered to be negligible.



TABLE XVI. The Degree of Limitation\* of the Soils at Sir Winston Churchill Provincial Park for Recreation Use

Mapping Unit	Camping Areas	Playground Areas	Picnic Areas	Hiking Trails	Permanent Buildings	Road Location and Subgrade Source	Sewage Disposal
Grandin							
I	6	6	5	5	2	5	5
II	4	6	4	4	2	5	5
III	4	6	4	4	2	5	5
IV	5	6	4	4	4	5	6
Winston							
I	5	6	5	5	2	5	5
II	4	6	4	4	2	5	5
III	4	6	4	4	2	5	5
IV	4	6	4	4	4	5	6
Lac La Biche							
II	5	6	5	4	4	5	5
Athabasca							
II	3	3	2	2	3	4	4
III	4	4	2	2	3	4	4
IV	4	6	4	2	4	4	5
Grosmont							
III	4	5	4	3	3	4	4
Maywood							
II	5	5	4	3	4	6	5
III	4	6	4	3	4	6	5
IV	4	6	5	3	6	6	6
V	6	6	6	4	6	6	6
Miquelon							
II	5	5	4	3	2	5	5
III	4	6	4	3	2	5	5
IV	4	6	5	3	4	5	6
Macola							
II	5	6	4	4	4	6	5
III	4	6	5	4	4	6	5
IV	4	6	6	4	6	6	6
Tawayik							
II	5	5	4	4	2	5	5
III	4	6	5	4	2	5	5



TABLE XVI. (Continued)

Mapping Unit	Camping Areas	Playground Areas	Picnic Areas	Hiking Trails	Permanent Buildings	Road Location and Subgrade Source	Sewage Disposal
Red Fox							
I	5	5	4	4	4	6	5
Snipe							
I	6	6	6	6	6	6	6
Sawdy							
I	6	6	6	6	6	6	6
Rich Lake							
I	4	4	4	4	4	6	4
Wanham							
I	6	6	6	6	6	6	6
Lacroix							
II	6	6	5	5	6	5	6
Culp							
III	2	4	2	4	3	6	6
V	6	6	6	5	6	6	6
Nestow							
II	5	4	3	4	3	6	6
III	4	4	4	4	3	6	6
IV	5	6	4	4	4	6	6
V	6	6	6	5	6	6	6
Edwand							
I	5	5	4	4	5	1	6
II	5	5	4	4	5	1	6
III	5	6	4	4	5	1	6
IV	6	6	4	4	5	1	6
Downing							
I	5	5	4	4	4	5	5
II	5	5	4	4	4	5	5
III	5	6	4	4	4	5	5
Medley							
I	2	4	2	5	4	6	6
II	2	4	2	5	4	6	6

\* 1 - no limitations

2 - slight limitations

3 - slight to mod. limitations

4 - mod. limitations

5 - mod. to severe limitations

6 - severe limitations



## VI. SUMMARY AND CONCLUSIONS

Recently, the increased demand and competition for land has resulted in an increased demand for careful land use planning. The planning of outdoor recreation areas is no exception. In studies conducted elsewhere soil survey information has been found essential to planning outdoor recreation areas. Thus, the purpose of this project is to provide some basic soil survey information for two Alberta provincial parks and to determine the applicability of the information in establishing suitability soil groupings for various outdoor recreation activities.

Detailed soil surveys were conducted and representative soils of dominant mapping units were characterized by chemical and physical analyses. Soils of the Luvisolic order were found to be dominant in both parks. Miquelon Lake Provincial Park is characterized by hummocky terrain on which the soils occur in a toposequence. Sir Winston Churchill Provincial Park, on the other hand, is characterized by very complex soil patterns on which topography appears to have no influence.

The soil characteristics selected for interpretive use are wetness, susceptibility to flooding, slope gradient, surface stoniness, permeability, surface soil texture, shrink-swell



potential, bulk density of the surface, liquidity index, the Unified rating, and soluble sulphate content. Wetness, susceptibility to flooding, and slope gradient are considered to affect all recreation activities. The others were used where applicable. The soil characteristics applicable to each recreation activity are separated into classes and the mapping units grouped accordingly.

The Luvisolic soils in both parks are considered to have moderate to severe limitations for all recreation uses and the Gleysolic soils are considered to have severe limitations. The continuing decline of the water level in Miquelon Lake may alleviate the severity of limitations of the Gleysolic soils at Miquelon Lake Provincial Park. The areal extent of soils with slight limitations for recreation use is minimal in both parks. Thus, careful planning, design, and management are required for the development of these two parks.

Although the findings of this study indicate most soils in the two parks have moderate to severe soil limitations for recreation use, it is not suggesting development should be avoided. The main purpose of soil survey information in recreation land use planning is to outline problem soils to the planners. Thus, soil survey information can be accepted as an essential aid in recreation land use planning but should not be considered as the only decision making tool.

Another important limitation of this study is that the soil limitation groupings presented are applicable only in the



areas considered. Extrapolation of the information to other geographical locations is not recommended because the groupings were established with the particular environmental conditions of each park in mind. The study was intended to provide interpretations of soil survey information for recreation use and not as a comprehensive interpretive classification system.



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## KEY TO APPENDICES

Topography and Drainage Classes: According to N.S.S.C. (1968).

Vegetation: Taxonomic name (common name).

- Trees: Populus tremuloides (Trembling Aspen), Populus balsamifera (Balsam Poplar), Abies balsamea (Balsam Fir), Betula papyrifera (White Birch), Picea glauca (White Spruce), Prunus americana (American Plum), Prunus pennsylvanica (Pin Cherry).
- Shrubs: Salix spp. (Willow), Rosa spp. (Rose), Cornus stolonifera (Red Osier Dogwood), Rubus strigosus (Wild Raspberry), Corylus cornuta (Beaked Hazelnut), Symphoricarpos albus (Snowberry), Sheperdia canadensis (Buffalo-berry), Amelanchier alnifolia (Saskatoon-berry), Viburnum edule (Low-bush Cranberry), Ribes glandulosum (Skunk berry), Ribes spp. (Gooseberry), Lonicera involucrata (Bracted Honeysuckle), Lonicera dioica (Twining Honeysuckle), Alnus spp. (Alder).
- Half-shrubs: Cornus canadensis (Bunchberry), Linnaea borealis (Twin Flower), Rubus pubescens (Dew berry).
- Herbs: Achillea millefolium (Common Tarrow), Actaea rubra (Red and White Baneberry), Aralia nudicaulis (Wild Sarsaparilla), Arnica cordifolia (Heartleaf Arnica), Aster conspicuus (Showy Aster), Aster spp. (Aster), Disporum trachycarpon (Fairy bells), Epilobium angustifolium (Fireweed), Fragaria virginiana (Wild Strawberry), Galium boreale (Northern Bedstraw), Galium trifolium (Sweet-scented Bedstraw), Heracleum lonatum (Cow Parsnip), Lathyrus ochroleucus (Peavine), Maianthemum canadense (Wild Lily-of-the-Valley), Mertensia paniculata (Bluebells), Mirtella nuda (Bishop's cap), Petasites palmatus (Palmate-leaved Colt's foot), Pyrola asarifolia



(Wintergreen), Streptopus amplexifolius (Twisted Stalk), Vicia americana (Vetch), Viola adunca (Early Blue Violet), Viola renifolia (Kidney-leaf Violet), Urtica gracilis (Common Nettles), Asclepias syriaca (Common Milkweed), Chenopodium album L. (Lamb's Quarters), Cirsium arvense (L.) Scop. (Canada Thistle), Geranium spp. (Geranium).

Grasses: Hordeum jubatum (Foxtail Barley), Festuca scabrella (Rough Fescue), Bromus spp. (Brome).

Ferns and

Fern Allies: Equisetum arvense L. (Field Horsetail).

Mosses: Ptilium spp. (Plum Moss), Hylocomium spp. (Feather Moss).

Profile Descriptions: According to N.S.S.C. (1968).

Abbreviations in Table of Data:

CaCO	Equiv. (%)	-	Calcium carbonate equivalent
Org. C	(%)	-	Organic carbon
meq		-	Millequivalents
TEC		-	Total exchange capacity
EC		-	Electrical conductivity
S		-	Sand (2 - 0.05 mm)
S <sub>1</sub>		-	Silt (0.05 - 0.002 mm)
C		-	Clay ( 0.002 mm)
LL		-	Liquid limit
PI		-	Plasticity index
LI		-	Liquidity index
Db		-	Bulk density
% M		-	Moisture
Ave		-	Average
Rge		-	Range
% Sat. Cap.		-	Saturation Capacity

X-ray Diffractograms:

_____	-	Heat treated sample
___ . ___ . ___ .	-	Glycolated sample



## APPENDIX AI

Morphological and Analytical Characteristics of the Soils  
at Miquelon Lake Provincial Park



Classification

Sub-group: Orthic Gray Luvisol  
 Series: Cooking Lake (Ck)  
 7th Approximation Equivalent: Typic Cryoboralf  
 Profile Number: M 55

Parent Material: Brown colored till  
 Topography: c slope; SE aspect  
 Elevation above Lake Level: 6.1 metres  
 Drainage Class: Moderately well

Vegetation and Cover Estimates:

Tree Canopy: P. tremuloides (20%), P. balsamifera (10%).

Shrubs: Rosa spp., C. stolonifera (1-5%), C. cornuta (1%), S. albes (15), A. alnifolia (1%), V. edule (1%), Ribes spp.

Half-shrubs: R. pubescens.

Herbs: A. rubra, F. virginiana, G. boreale, H. lonatum, V. americana, V. adunca, Geranium spp.



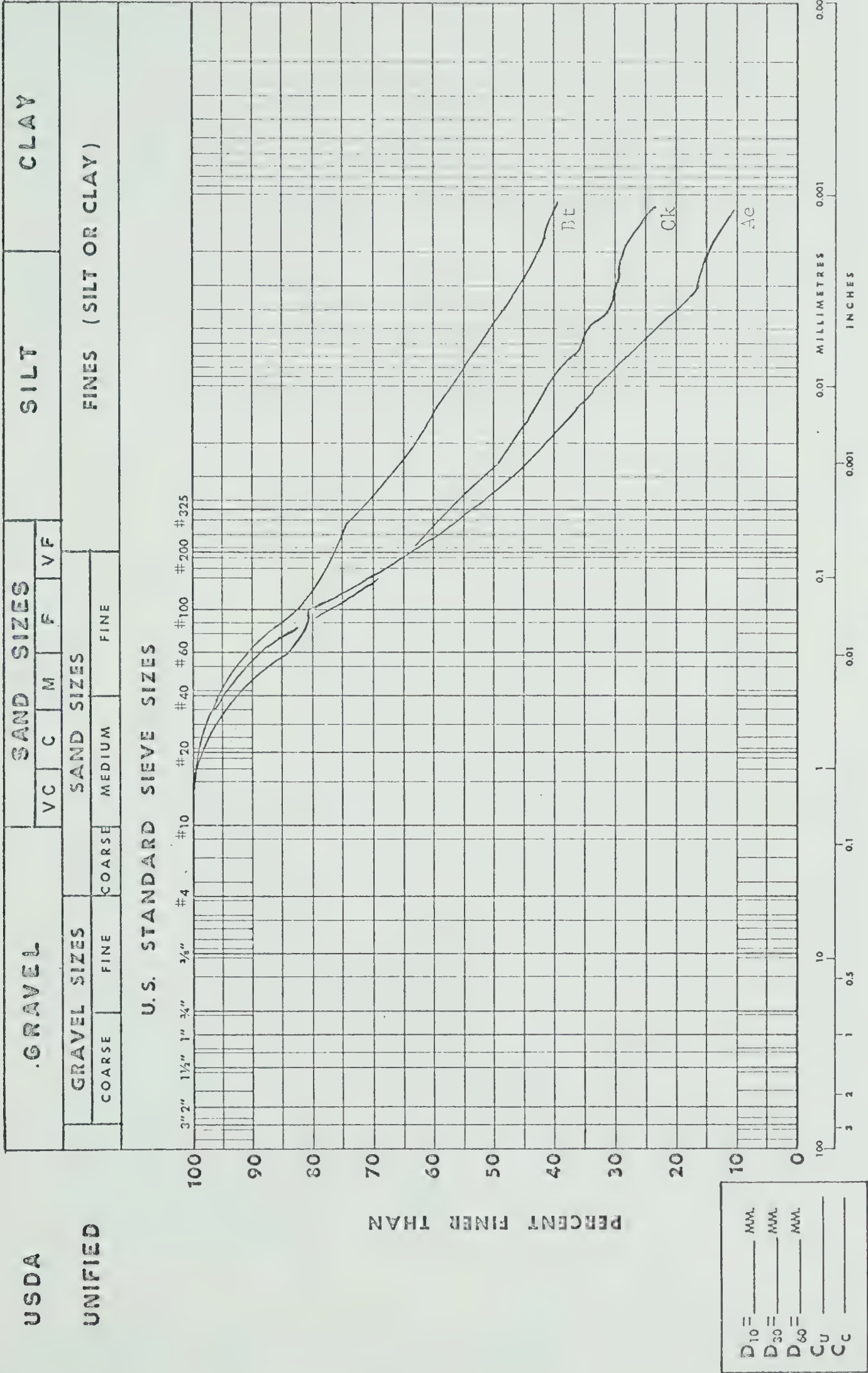
<u>HORIZON</u>	<u>DEPTH (cm.)</u>	<u>DESCRIPTION</u>
L-H	5-0	Very dark brown (7.5YR 2/2) when dry; semi-decomposed leaf matter.
Ae	0-23	Dark brown (10YR 4/3) when moist and pale brown (10YR 5.5/3) when dry; L; moderate medium platy; friable and slightly hard; abundant fine and medium random roots and few coarse horizontal roots; many very fine vesicular and interstitial pores; pH 6.3; clear smooth boundary; 20 to 25 cm. thick.
AB	23-27	Not sampled or described.
Bt	27-62	Very dark grayish brown (10YR 3/2) when moist and gray (10YR 5.5/1) when dry; C; moderate medium columnar macro-structure and strong fine and medium sub-angular blocky meso-structure; firm and hard; plentiful fine vertical exped roots and plentiful medium vertical and horizontal exped roots; common very fine vesicular and interstitial pores; many thin clay films on vertical ped surfaces and common thin clay films on horizontal ped surfaces; pH 5.9; clear smooth boundary; 30 to 40 cm. thick.
Bck	62-75	Very dark grayish brown (10YR 3/2) exterior color when moist and gray (10YR 5.5/1) when dry and dark yellowish brown (10YR 4/4) interior color when moist and yellowish brown to light yellowish brown (10YR 5.5/4) when dry; C; moderate fine and medium sub-angular blocky; firm and hard; few fine vertical exped roots and plentiful medium vertical exped roots; common very fine vesicular and interstitial pores; common thin clay films on vertical ped surfaces; very weakly effervescent; pH 7.0; clear smooth boundary; 10 to 15 cm. thick.
BCca	75-100	Gray (10YR 6/1) exterior color when dry and yellowish brown to light yellowish brown (10YR 5.5/4) interior color when dry with light gray (10YR 7/2) carbonate accumulations when dry; C; moderate fine and medium sub-angular blocky; firm and hard; plentiful fine and medium vertical exped roots; common very fine vesicular pores and few very fine interstitial pores; few thin clay films; common fine distinct carbonate accumulations; moderately effervescent; pH 7.2; clear smooth boundary; 20 to 30 cm. thick.
Cca	100-130	Dark gray (10YR 4/1) when moist and gray (10YR 6/1) when dry and dark yellowish brown (10YR 4/4) when moist and light yellowish brown (10YR 6/3) when dry with light gray (10YR 7/2) carbonate accumulations; CL; massive; friable and hard; few roots; common very fine vesicular pores; many fine distinct carbonate accumulations; strongly effervescent; pH 7.4; clear smooth boundary; 25 to 35 cm. thick.
Ck	130-150+	Dark gray (10YR 4/1) when moist and gray (10YR 6/1) when dry and dark yellowish brown (10YR 4/4) when moist and light yellowish brown (10YR 6/3) when dry; CL-SCL; massive; friable and hard; very few roots; few very fine vesicular pores; moderately effervescent; pH 7.5.



Profile Number M. 55

Horizon		Ae	Bt	BCK	BCca	Cca	Ck
Depth(cm)		0-23	27-62	62-75	75-100	100-130	130-150+
CHEMICAL ANALYSES							
pH		6.3	5.9	7.0	7.2	7.4	7.5
CaCO <sub>3</sub> Equiv.(%)		-	-	0.42	4.85	12.36	5.62
Org. C(%)		0.96	0.68	-	-	-	-
Exchange	H	2.09	1.94	0.19	-	-	-
Analysis	Ca	4.5	13.6	15.3	28.0	46.0	48.0
(meq/100 g)	Mg	4.1	11.1	11.8	11.1	13.0	9.4
	K	0.86	0.74	0.75	0.76	0.70	0.60
	Na	0.04	0.81	0.99	0.53	1.16	0.74
	TEC	9.7	21.1	25.2	25.0	18.9	13.4
Soluble	Ca	-	-	-	5.78	11.00	12.75
Salts	Mg	-	-	-	4.10	8.69	6.23
(meq/l)	Na	-	-	-	26.52	26.78	33.91
	SO <sub>4</sub>	-	-	-	26.56	57.06	53.13
EC(mmhos/cm)		-	-	-	2.40	4.25	4.00
PHYSICAL ANALYSES							
Particle	S	45	26	26	20	29	42
Size	Si	40	32	32	36	35	30
Analysis(%)	C	15	42	42	44	36	28
USDA Text. Class		L	C	C	C	CL	CL-SCL
Unified Rating		ML	CL	-	-	-	CL
Atterberg	LL	18	42	-	-	-	31
Limits(%)	PI	2	18	-	-	-	13
	LI	1.5	-3.9	-	-	-	-0.08
Bulk	Db	1.35	1.40	1.38	-	-	-
Density(g/cc)	%M	8	16	19	-	-	-
Penetrometer	Ave	0.95	2.38	-	-	-	3.37
(kg/cm <sup>2</sup> )	Rge	0.5-1.6	1.7-2.9	-	-	-	2.9-4.0
% Nat. M		19	17	-	-	-	17
% Hygro.M		1.04	3.30	3.32	3.34	2.70	2.43
% 15 bar M		7.8	17.8	20	21	20	14
% 1/3 bar M		18	30	29	31	35	25
% 1/10 bar M		-	-	-	-	-	-
% Sat. Cap.		-	-	-	58	61	43







Angstroms

3.32

7.0

10.0

14.0

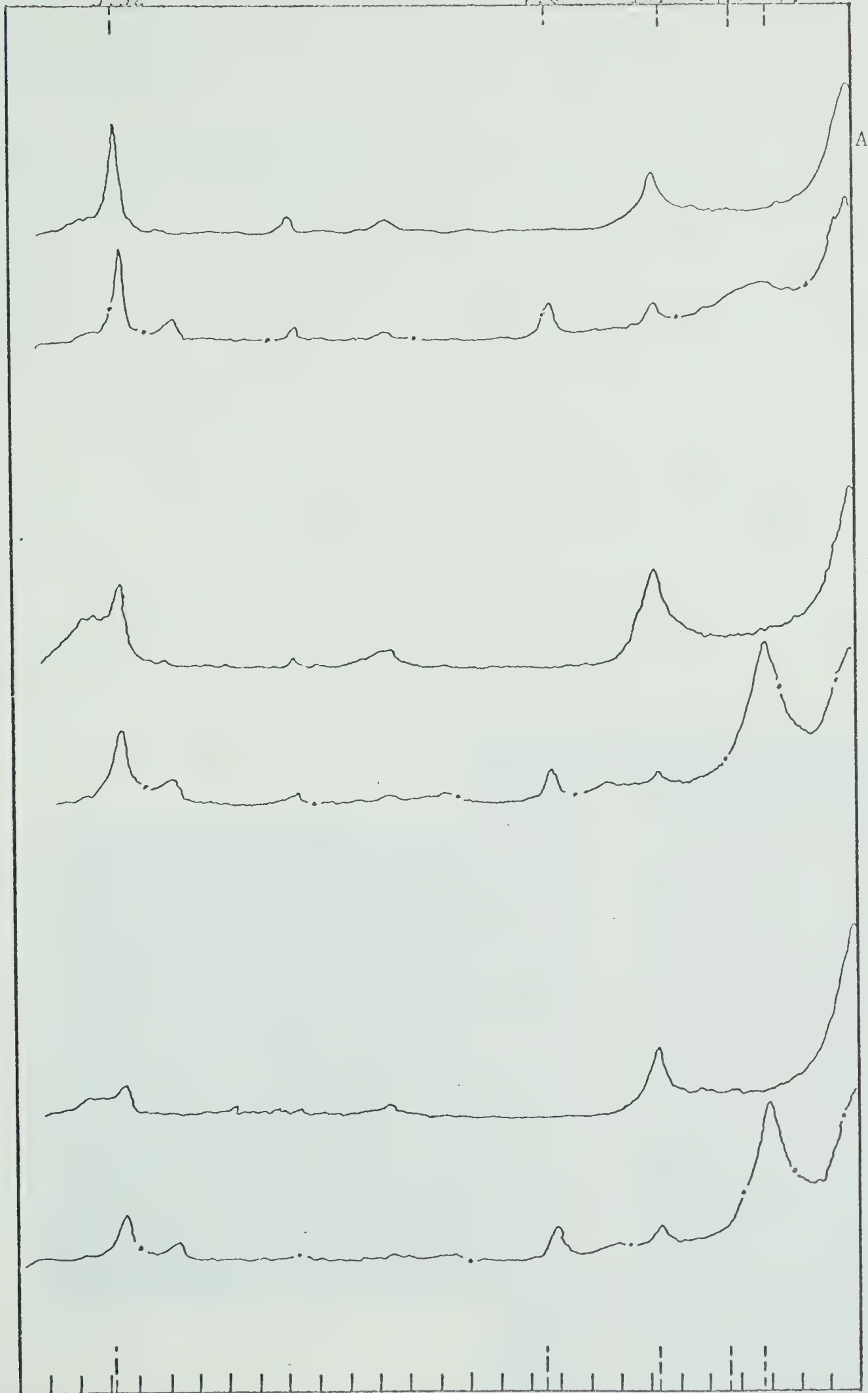
17.0

Ae

Bt

Ck

30 28 26 24 22 20 18 16 14 12 10 8 6 4 2  
Degrees 2θ





Classification

Sub-group: Orthic Gray Luvisol  
 Series: Cooking Lake (Ck)  
 7th Approximation Equivalent: Typic Cryoboralf  
 Profile Number: M. 237

Parent Material: Brown colored till  
 Topography: d slope; W aspect  
 Elevation above Lake Level: 19.8 metres  
 Drainage Class: Moderately well

Vegetation and Cover Estimates:

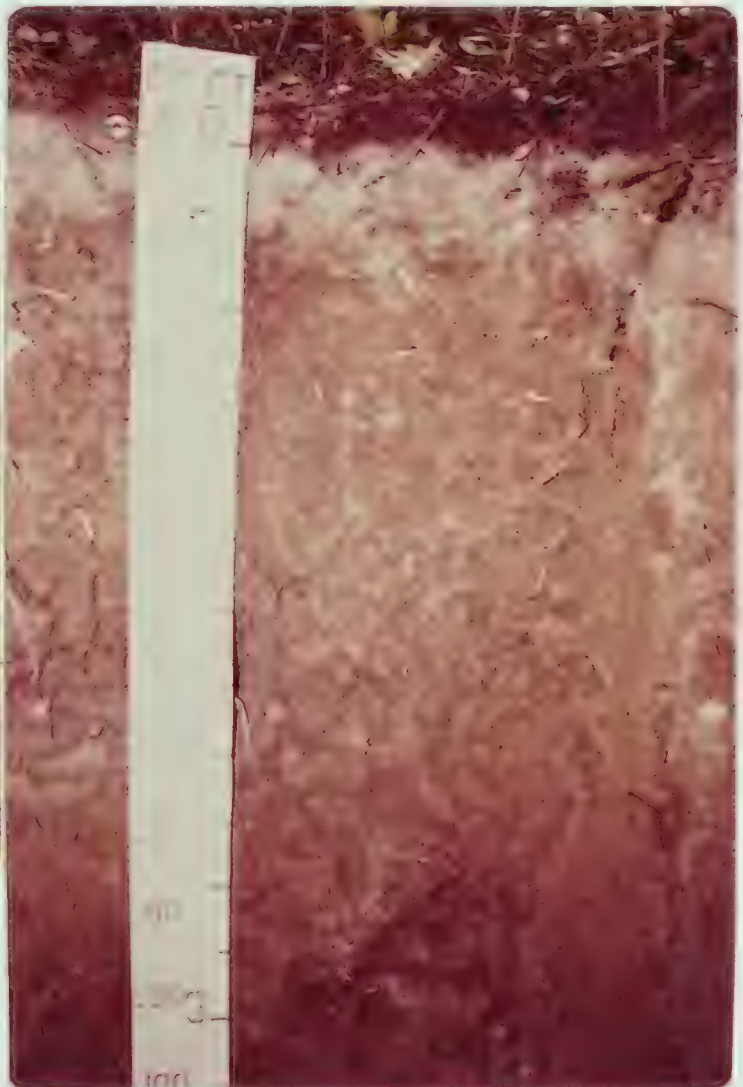
Tree Canopy: P. tremuloides (30%).

Shrubs: Rosa spp., C. stolonifera (1-5%), R. strigosus (1%), C. cornuta (1-5%), S. albus (1%), S. canadensis, A. alnifolia (1%), V. edule (1%).

Half-shrubs: C. canadensis, L. borealis, R. pubescens.

Herbs: A. millefolium, A. nudicaulis, A. cordifolia, A. conspicuus, Aster spp., G. boreale, L. ochroleucus, P. asarifolia, S. amplexifolius, V. americana.

Grass: F. scabrella.





<u>HORIZON</u>	<u>DEPTH (cm.)</u>	<u>DESCRIPTION</u>
L-H	2-0	Semi- and well decomposed leaf matter.
Ah	0-2	Not described or sampled.
Ae	2-13	Brown (10YR 5/3) when moist and pale brown (10YR 6/3) when dry; SCL-SL; moderate medium platy; slightly plastic, friable, slightly hard; plentiful fine vertical roots, abundant medium horizontal roots, and plentiful coarse horizontal roots; many very fine vesicular pores and common very fine interstitial pores; pH 5.9; clear smooth boundary; 7 to 15 cm. thick.
AB	13-25	Dark brown to dark yellowish brown (10YR 4/3.5) when moist and yellowish brown (10YR 5/4) when dry; SCL; weak fine sub-angular blocky; plastic, friable, and hard; plentiful fine vertical roots, abundant medium vertical and horizontal roots, and few coarse horizontal roots; many very fine vesicular and interstitial pores; pH 5.3; clear smooth boundary; 7 to 15 cm. thick.
Bt <sub>1</sub>	25-38	Dark yellowish brown (10YR 3/4) exterior color when moist and yellowish brown (10YR 5/4) when dry and dark yellowish brown (10YR 4/4) interior color when moist and yellowish brown (10YR 5/4) when dry; SCL; moderately strong fine sub-angular blocky; plastic, friable, and hard; plentiful fine vertical roots and abundant medium random roots; many very fine interstitial pores; common thin clay films on vertical ped surfaces and few thin clay films on horizontal ped surfaces; pH 5.0; clear smooth boundary; 10 to 15 cm. thick.
Bt <sub>2</sub>	38-58	Dark yellowish brown (10YR 4/4) exterior color when moist and yellowish brown (10YR 5/4) when dry and dark yellowish brown (10YR 3.5/4) interior color when moist and yellowish brown (10YR 5/4) when dry; SCL; weak medium prismatic macro-structure and strong fine and medium sub-angular blocky meso-structure; plastic, firm, and very hard; plentiful fine vertical roots and plentiful medium random roots; few very fine vesicular pores and common very fine interstitial pores; many thin clay films on vertical meso-structure surfaces, common thin clay films on horizontal meso-structure surfaces, and continuous thin clay films on vertical macro-structure surfaces; pH 4.9; clear smooth boundary; 17 to 23 cm. thick.
Bck <sub>1</sub>	58-85	Dark yellowish brown (10YR 4/4) when moist and yellowish brown (10YR 5.5/4) when dry; CL; weak medium prismatic to massive; plastic, firm, and very hard; plentiful fine vertical roots; common very fine vesicular pores and few very fine interstitial pores; common thin clay films on vertical ped surfaces; very weakly effervescent; pH 6.2; clear smooth boundary; 22 to 30 cm. thick.
Bck <sub>2</sub>	85-103	Dark yellowish brown (10YR 4/4) when moist and yellowish brown (10YR 5.5/4) when dry; CL; weak medium prismatic to massive; plastic, firm, and very hard; plentiful fine vertical roots; common very fine vesicular pores and few very fine interstitial pores; common thin clay films on vertical ped surfaces; moderately effervescent; pH 7.0; clear smooth boundary; 14 to 20 cm. thick.
Ck	103-160+	Dark gray (10YR 4/1) and dark brown (10YR 4/3) when moist and gray (10YR 5.5/1) and brown to pale brown (10YR 5.5/3) when dry with light gray (10YR 7/2) carbonate accumulations; SCL; massive; slightly plastic, firm, and hard; few roots; common very fine vesicular pores; few fine distinct carbonate accumulations; moderate to strongly effervescent; pH 7.5.



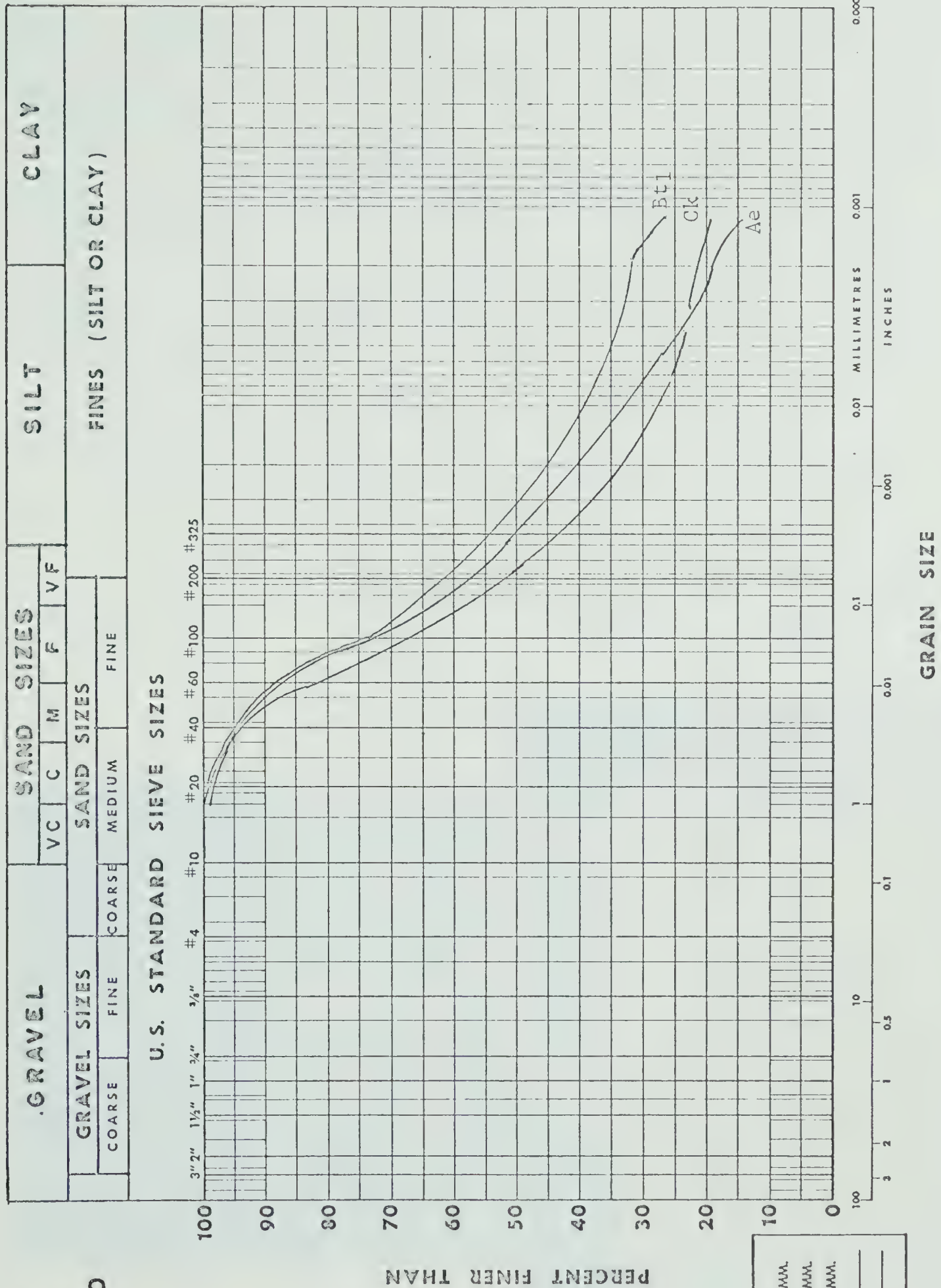
Profile Number M. 237

Horizon		Ae	AB	Bt <sub>1</sub>	Bt <sub>2</sub>	BCK <sub>1</sub>	BCK <sub>2</sub>	Ck
Depth(cm)		2-13	13-35	25-38	38-58	58-85	85-103	103-160+
CHEMICAL ANALYSES								
pH		5.9	5.3	5.0	4.9	6.2	7.0	7.5
CaCO <sub>3</sub> Equiv.(%)		-	-	-	-	-	3.95	6.39
Org. C(%)		0.88	0.76	0.39	0.57	-	-	-
Exchange	H	1.84	2.87	3.58	3.21	0.77	0.23	-
Analysis	Ca	6.4	9.2	9.4	9.4	14.6	25.2	18.8
(meq/100 g)	Mg	3.2	5.7	6.4	6.0	6.8	6.2	8.6
	K	0.33	0.43	0.36	0.29	0.28	0.31	0.19
	Na	0.02	0.03	0.06	0.07	0.08	0.09	0.07
	TEC	10.1	17.8	19.6	18.4	18.6	17.0	9.2
Soluble	Ca	-	-	-	-	-	-	-
Salts	Mg	-	-	-	-	-	-	-
(meq/l)	Na	-	-	-	-	-	-	-
	SO <sub>4</sub>	-	-	-	-	-	-	-
EC(mmhos/cm)		-	-	-	-	-	-	-
PHYSICAL ANALYSES								
Particle	S	49	47	44	46	40	42	54
Size	Si	32	25	24	23	29	28	25
Analysis(%)	C	19	28	32	31	31	30	21
USDA Text. Class		SCL-SL	SCL	SCL	SCL	CL	CL-SCL	SCL
Unified Rating		CL-ML	-	CL	-	-	-	CL
Atterberg	LL	22	-	31	-	-	-	24
Limits(%)	PI	7	-	15	-	-	-	8
	LI	2.5	-	0.14	-	-	-	-0.25
Bulk	Db	1.43	1.34	1.36	1.53	1.52	-	-
Density(g/cc)	%M	14	19	18	13	12	-	-
Penetrometer	Ave	1.02	-	2.26	-	-	-	4.3
(kg/cm <sup>2</sup> )	Rge	0.7-1.5	-	1.8-3.1	-	-	-	-
% Nat. M		18	-	18	-	-	-	14
% Hygro. M		1.21	2.40	2.52	2.26	2.82	2.26	1.32
% 15 bar M		9	11	12	6	8	6	4
% 1/3 bar M		20	21	22	22	26	26	18
% 1/10 bar M		-	-	-	-	-	-	-
% Sat. Cap.		-	-	-	-	-	-	-



406

DEWEY





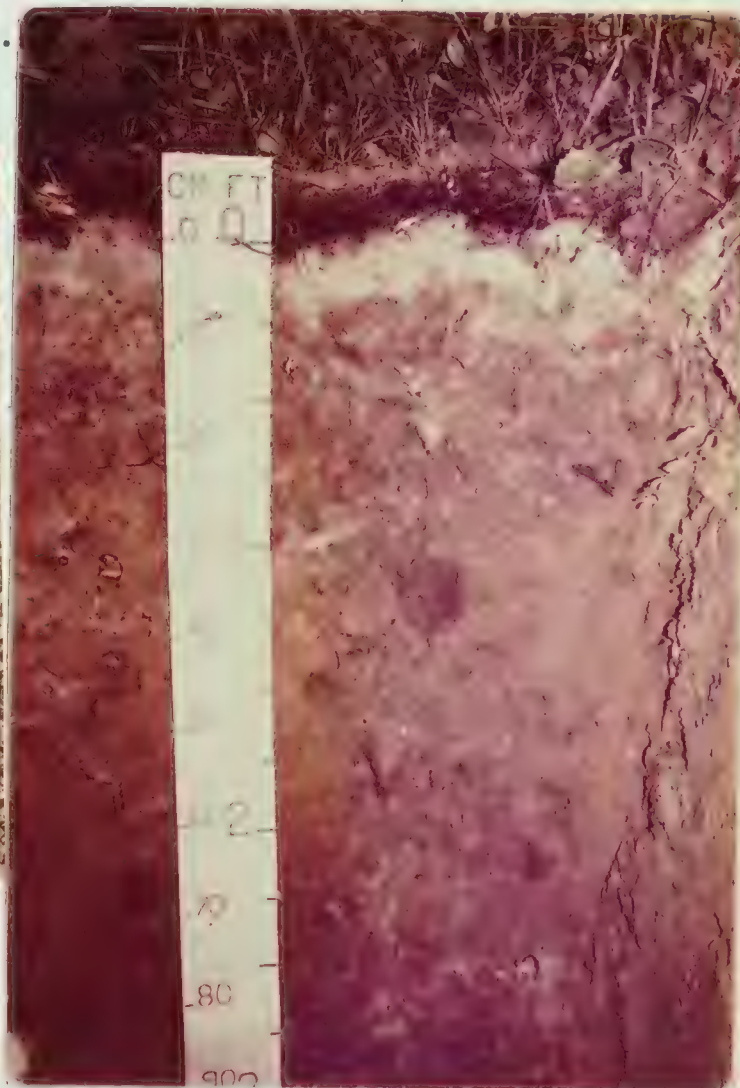
Classification

Sub-group: Orthic Gray Luvisol  
Series: Coarse Cooking Lake (C.Ck)  
7th Approximation Equivalent: Typic Cryoboralf  
Profile Number: M. 197

Parent Material: Stony brown till  
Topography: c slope; SW aspect  
Elevation above Lake Level: 18.3 metres  
Drainage Class: Well drained

Vegetation and Cover Estimates:

Tree Canopy: P. tremuloides (30%)  
Shrubs: Salix spp. (1-5%), Rosa spp., C. cornuta (1%), S. albus (1%).  
Half-shrubs: C. canadensis, L. borealis, R. pubescens.  
Herbs: A. nudicaulis, A. cordifolia, A. conspicuus,  
Aster spp., E. angustifolium, F. virginiana,  
G. boreale, M. canadense, V. americana,  
V. adunca.  
Grasses: F. scabrella.





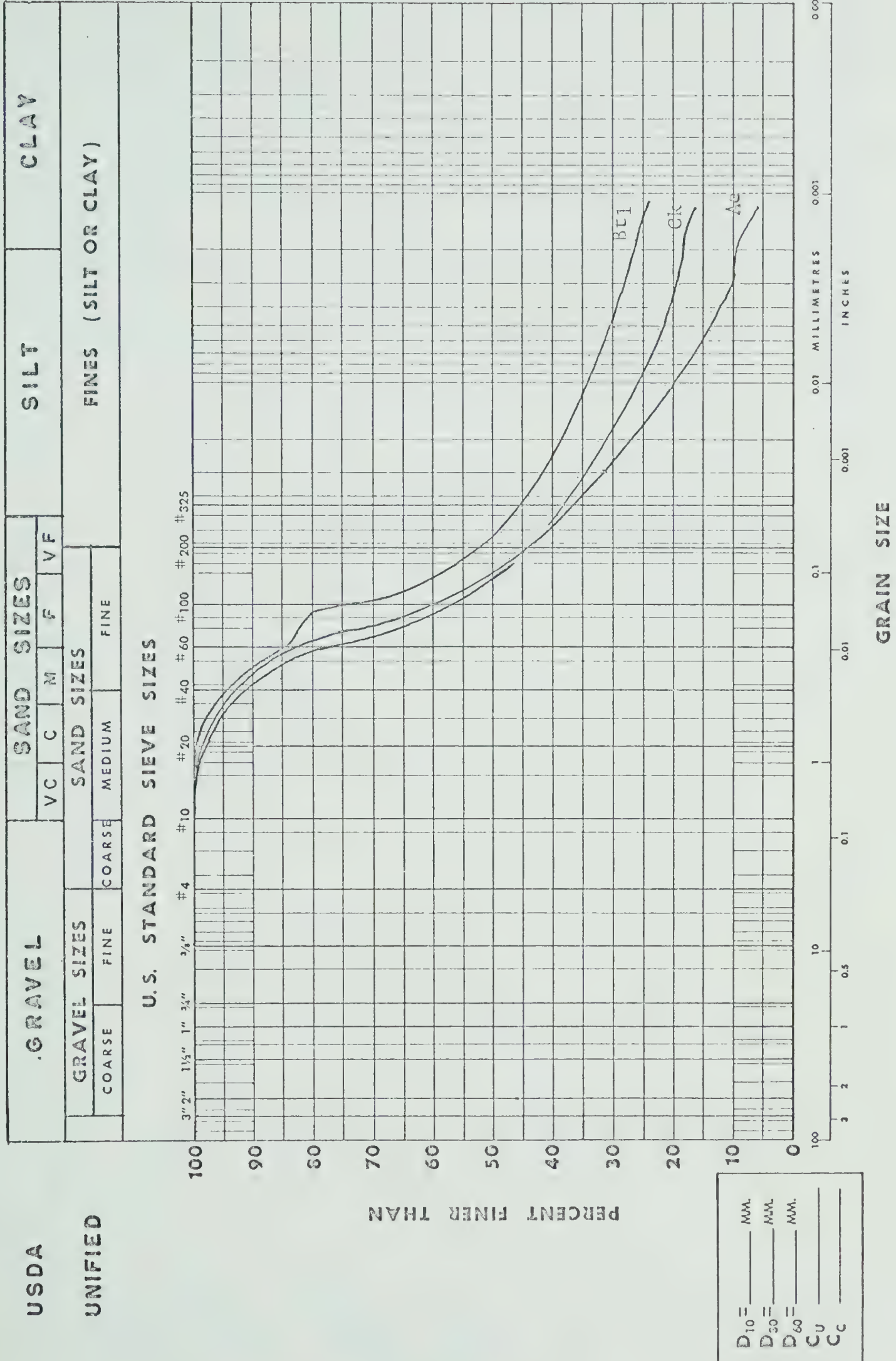
<u>HORIZON</u>	<u>DEPTH (cm.)</u>	<u>DESCRIPTION</u>
L-H	2-0	Semi- and well decomposed leaf matter.
Ae	0-10	Dark yellowish brown (10YR 3/4) when moist and very pale brown (10YR 7/3) when dry; SL; weak medium platy; non-plastic, very friable, and soft; abundant fine vertical roots, abundant medium horizontal roots, and plentiful random coarse roots; many very fine vesicular pores; pH 6.6; clear smooth boundary; 7 to 13 cm. thick.
AB	10-12	Not described or sampled.
Bt <sub>1</sub>	12-30	Dark brown to dark yellowish brown (10YR 4/3.5) when moist and brown to yellowish brown (10YR 5.5/3.5) when dry; SCL; moderate fine sub-angular blocky; slightly plastic, friable, and hard; plentiful fine vertical roots, plentiful medium horizontal roots, and few coarse roots; common very fine vesicular pores and many very fine interstitial pores; common thin clay films on vertical ped surfaces and few thin clay films on horizontal ped surfaces; common pebbles and few cobbles; pH 5.7; abrupt smooth boundary; 15 to 20 cm. thick.
Bt <sub>2</sub>	30-50	Brown to strong brown (7.5YR 4/5) when moist and dark yellowish brown (10YR 4.5/4.5) when dry; SCL; weak medium sub-angular blocky; slightly plastic, friable, and slightly hard; common fine vertical roots and few medium horizontal roots; common very fine vesicular pores; common thin clay films on vertical ped surfaces; pH 5.9; clear smooth boundary; 15 to 25 cm. thick.
BC <sub>1</sub>	50-70	Dark yellowish brown (10YR 4/6) when moist and brownish yellow (10YR 5.5/6) when dry; SL-SCL; weak sub-angular blocky to massive; slightly plastic, firm, and hard; few fine and medium vertical roots; many very fine vesicular pores and few very fine interstitial pores; few thin clay films on vertical ped surfaces; common pebbles and cobbles; pH 6.2; clear smooth boundary; 15 to 23 cm. thick.
BC <sub>2</sub>	70-80	Dark yellowish brown (10YR 4/4) when moist and yellowish brown (10YR 5/5) when dry; SL-SCL; weak sub-angular blocky to massive; slightly plastic, friable, and hard; few fine and medium vertical roots; many very fine vesicular pores and few very fine interstitial pores; pH 7.2; abrupt smooth boundary; 7 to 13 cm. thick.
Ck	80-145+	Dark gray (10YR 4/1) and brown (7.5YR 4.5/4) when moist and gray (10YR 6/1) and yellowish brown (10YR 5.5/4) when dry with light gray (10YR 7/2) carbonate accumulations; SL-SCL; massive; slightly plastic, friable, and hard; few fine and medium vertical roots; common very fine vesicular pores and few very fine interstitial pores; common fine distinct carbonate accumulations; moderate to strongly effervescent; pH 7.6-7.8.



Profile Number M. 197

Horizon		Ae	Bt <sub>1</sub>	Bt <sub>2</sub>	BC <sub>1</sub>	BC <sub>2</sub>	Ck	Ck
Depth(cm)		0-10	12-30	30-50	50-70	70-80	80-100	100-145+
CHEMICAL ANALYSES								
pH		6.6	5.7	5.9	6.2	7.2	7.6	7.8
CaCO <sub>3</sub> Equiv.(%)		-	-	-	-	0.85	6.54	6.56
Org. C(%)		0.43	0.47	0.44	-	-	-	-
Exchange	H	0.89	1.97	1.12	0.89	-	-	-
Analysis	Ca	2.5	9.9	7.4	7.7	11.1	-	-
(meq/100 g)	Mg	1.3	4.0	4.1	4.1	4.5	-	-
	K	0.20	0.45	0.31	0.28	0.21	-	-
	Na	0.04	0.10	0.08	0.06	0.04	-	-
	TEC	3.6	15.4	11.5	11.4	11.2	-	-
Soluble	Ca	-	-	-	-	-	-	1.45
Salts	Mg	-	-	-	-	-	-	0.57
(meq/l)	Na	-	-	-	-	-	-	0.66
	SO <sub>4</sub>	-	-	-	-	-	-	0.20
EC(mmhos/cm)		-	-	-	-	-	-	0.43
PHYSICAL ANALYSES								
Particle	S	62	54	64	62	62	62	54
Size	Si	29	19	14	18	18	20	23
Analysis(%)	C	9	27	22	20	20	18	23
USDA Text. Class		SL	SCL	SCL	SL-SCL	SL-SCL	SL	SCL
Unified Rating		SC	CL	-	-	-	SC	-
Atterberg	LL	13	29	-	-	-	22	-
Limits(%)	PI	-	12	-	-	-	9	-
	LI	-	0.25	-	-	-	0.33	-
Bulk	Db	1.45	1.45	1.54	1.48	-	-	-
Density(g/cc)	%M	12	15	10	7	-	-	-
Penetrometer	Ave	1.21	1.84	-	-	-	4.04	-
(kg/cm <sup>2</sup> )	Rge	0.7-1.8	1.2-2.3	-	-	-	3.2-4.3	-
% Nat. M		15	20	-	-	-	16	-
% Hygro. M		1.31	1.66	1.27	1.37	1.05	1.13	1.54
% 15 bar M		3	10	7	7	7	6	8
% 1/3 bar M		11	19	15	15	15	15	17
% 1/10 bar M		-	-	-	-	-	-	-
% Sat. Cap.		-	-	-	-	-	-	32







Angstroms

3.32

7.0

10.0

14.0

17.0

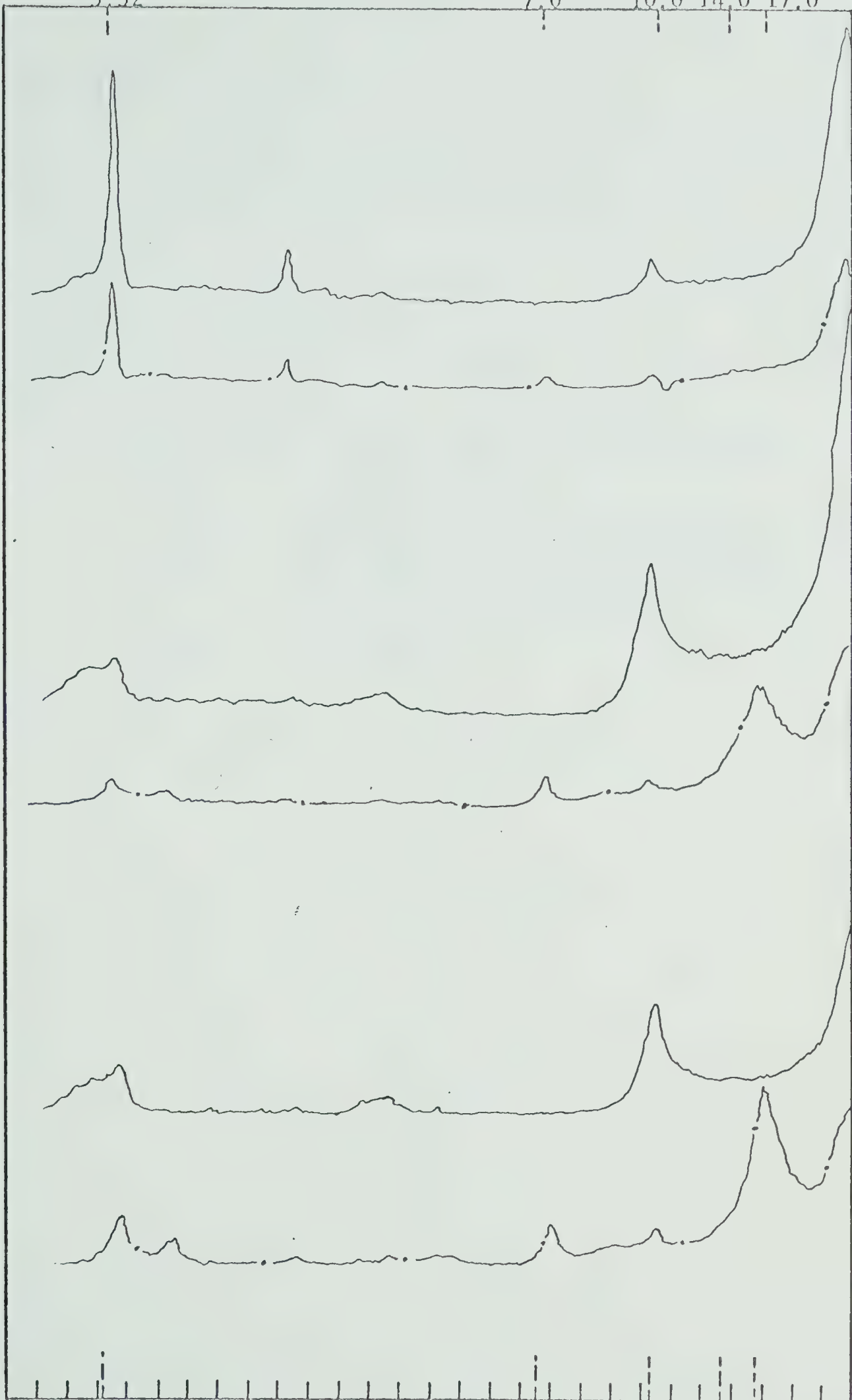
Ae

Bt<sub>1</sub>

Ck

30 28 26 24 22 20 18 16 14 12 10 8 6 4 2

Degrees 2θ





Classification

Sub-group: Orthic Dark Gray Luvisol  
Series: Uncas (Un)  
7th Approximation Equivalent: Mollic Cryoboralf  
Profile Number: M. 162

Parent Material: Brown colored till  
Topography: c slope; NW aspect  
Elevation above Lake Level: 13.7 metres  
Drainage Class: Moderately well to well

Vegetation and Cover Estimates:

Tree Canopy: P. tremuloides (20%), P. balsamifera,  
P. glauca (1%).  
Shrubs: Salix spp. (1-5%), Rosa spp., C.  
stolonifera (1-5%), R. strigosus (1%).  
Herbs: A. conspicuous, E. angustifolium, H.  
lonatum, U. gracilis.  
Grasses: F. scabrella.



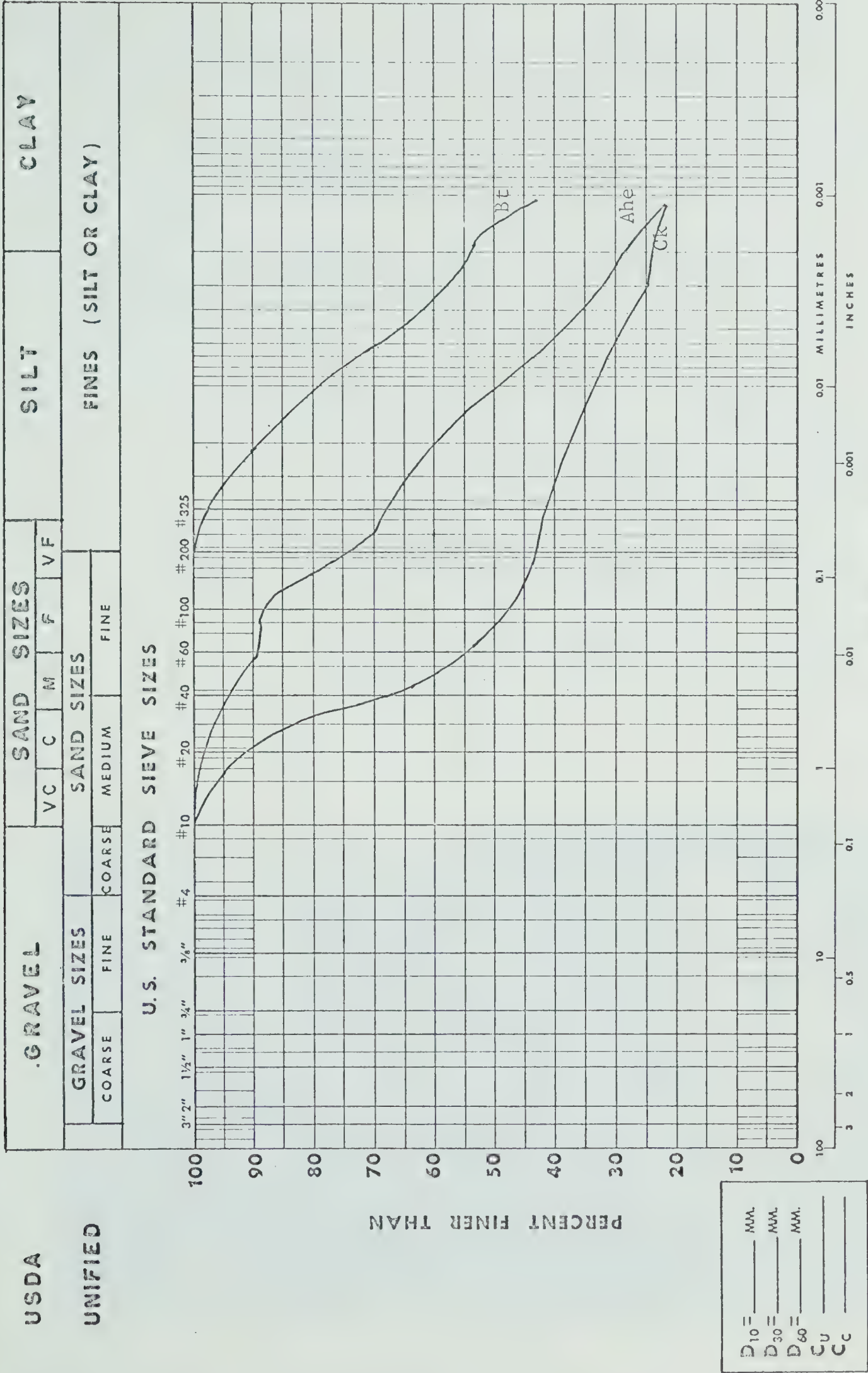
<u>HORIZON</u>	<u>DEPTH (cm.)</u>	<u>DESCRIPTION</u>
L-H	5-0	Semi-decomposed leaf and grass matter.
Ahe	0-15	Very dark grayish brown (10YR 3/2) when moist and very dark brown (10YR 2/3) when dry; CL; weak medium platy; very friable and slightly hard; abundant fine and medium random roots and abundant coarse horizontal roots; many very fine vesicular and interstitial pores; pH 7.3; clear smooth boundary; 7 to 18 cm. thick.
Ae	15-39	Dark grayish brown (10YR 4/2) when moist and grayish brown (10YR 5/2) when dry; L; moderately strong medium platy; friable and slightly hard to hard; abundant fine vertical roots, plentiful medium horizontal and vertical roots and plentiful coarse horizontal roots; many very fine vesicular and interstitial pores; pH 6.9; gradual smooth boundary; 17 to 32 cm. thick.
AB	39-57	Dark brown (10YR 4/3) when moist and brown (10YR 5/3) when dry; L; moderate fine sub-angular blocky to weak fine platy; firm and hard; plentiful fine and medium vertical roots; common very fine vesicular pores and many very fine interstitial pores; pH 6.8; clear smooth boundary; 10 to 20 cm. thick.
Bt	57-105	Very dark gray (10YR 3.5/1) exterior ped color when moist and gray (10YR 5.5/1) when dry and yellowish brown (10YR 5/4) interior ped color when moist and light yellowish brown (10YR 6/4) when dry; SiC; weak medium prismatic macro-structure and moderately strong fine and medium sub-angular blocky meso-structure; firm to very firm and very hard; plentiful fine vertical roots and few medium vertical roots; few very fine vesicular pores and common very fine interstitial pores; many thin discontinuous clay films on vertical ped surfaces and common thin discontinuous clay films on horizontal ped surfaces; pH 6.8; abrupt smooth boundary; 45 to 53 cm. thick.
Bck	105-160	Brown to pale brown (10YR 5.5/3) when moist and brown (10YR 4.5/3) when dry; CL; weak medium sub-angular blocky to massive; firm and hard; few fine vertical roots; common very fine vesicular pores and few very fine interstitial pores; common thin clay films on vertical ped surfaces; very weakly effervescent; pH 7.7; clear smooth boundary; 45 to 58 cm. thick.
Ck	160-180+	Dark grayish brown to dark brown (10YR 4/2.5) when moist and grayish brown to brown (10YR 5/2.5); SCL; massive structure; firm and hard; weakly effervescent; stony; pH 7.7.



Profile Number M. 162

Horizon		Ahe	Ae	AB	Bt	Bck	Ck
Depth(cm)		0-15	15-39	39-57	57-105	105-160	160-180+
CHEMICAL ANALYSES							
pH		7.3	6.9	6.8	6.8	7.7	7.7
CaCO <sub>3</sub> Equiv.(%)		0.42	-	-	-	2.40	2.93
Org. C(%)		9.88	1.20	0.49	0.92	-	-
Exchange	H	-	1.51	0.77	1.08	-	-
Analysis	Ca	27.2	7.9	5.9	16.1	-	-
(meq/100 g)	Mg	11.1	6.5	5.6	10.3	-	-
	K	3.40	2.26	1.93	1.69	-	-
	Na	2.70	0.71	0.26	0.90	-	-
	TEC	46.1	16.5	13.0	28.1	-	-
Soluble	Ca	-	-	-	-	-	2.48
Salts	Mg	-	-	-	-	-	2.05
(meq/l)	Na	-	-	-	-	-	4.61
	SO <sub>4</sub>	-	-	-	-	-	9.78
EC(mmhos/cm)		-	-	-	-	-	1.40
PHYSICAL ANALYSES							
Particle	S	32	26	36	2	32	58
Size	Si	40	48	39	45	27	18
Analysis(%)	C	28	26	25	53	41	24
USDA Text. Class		CL	L	L	SiC	CL	SCL
Unified Rating		-	-	-	ML	-	SC
Atterberg	LL	84	-	-	47	-	25
Limits(%)	PI	-	-	-	19	-	9
	LI	-	-	-	-0.50	-	0.33
Bulk	Db	0.50	1.35	-	1.50	1.57	-
Density(g/cc)	%M	37	20	-	16	14	-
Penetrometer	Ave	0.80	1.29	-	2.70	-	2.80
(kg/cm <sup>2</sup> )	Rge	0.5-1.1	0.7-2.0	-	2.0-3.1	-	2.2-3.7
% Nat. M		40	22	-	19	-	19
% Hygro. M		11.97	1.81	1.76	3.38	3.50	0.67
% 15 bar M		40	10	8	18	15	8
% 1/3 bar M		56	23	19	34	24	17
% 1/10 bar M		-	-	-	-	-	-
% Sat. Cap.		-	-	-	-	-	37







Classification

Sub-group: Gray Solod

Series: Monique (Mq)

7th Approximation Equivalent: Glossic Natriboralf

Profile Number: M. 27

Parent Material: Lacustrine clay / brown colored till

Topography: b slope; N aspect

Elevation above Lake Level: 7 metres

Drainage Class: Imperfect

Vegetation and Cover Estimates:

Tree Canopy: P. tremuloides (15%), P. balsamifera (15%).

Shrubs: Rosa spp., C. stolonifera (5%), R. strigosus (1%), S. albus (1%), A. alnifolia, Ribes spp., L. involucrata.

Half-shrubs: C. canadensis, L. borealis, R. pubescens.

Herbs: A. millefolium, A. nudicaulis, A. cordifolia, A. conspicuous, F. virginiana, G. boreale, L. ochroleucus, M. canadense, M. paniculata, P. palmatus, P. asarifolia, V. americana.

Grasses: F. scabrella.





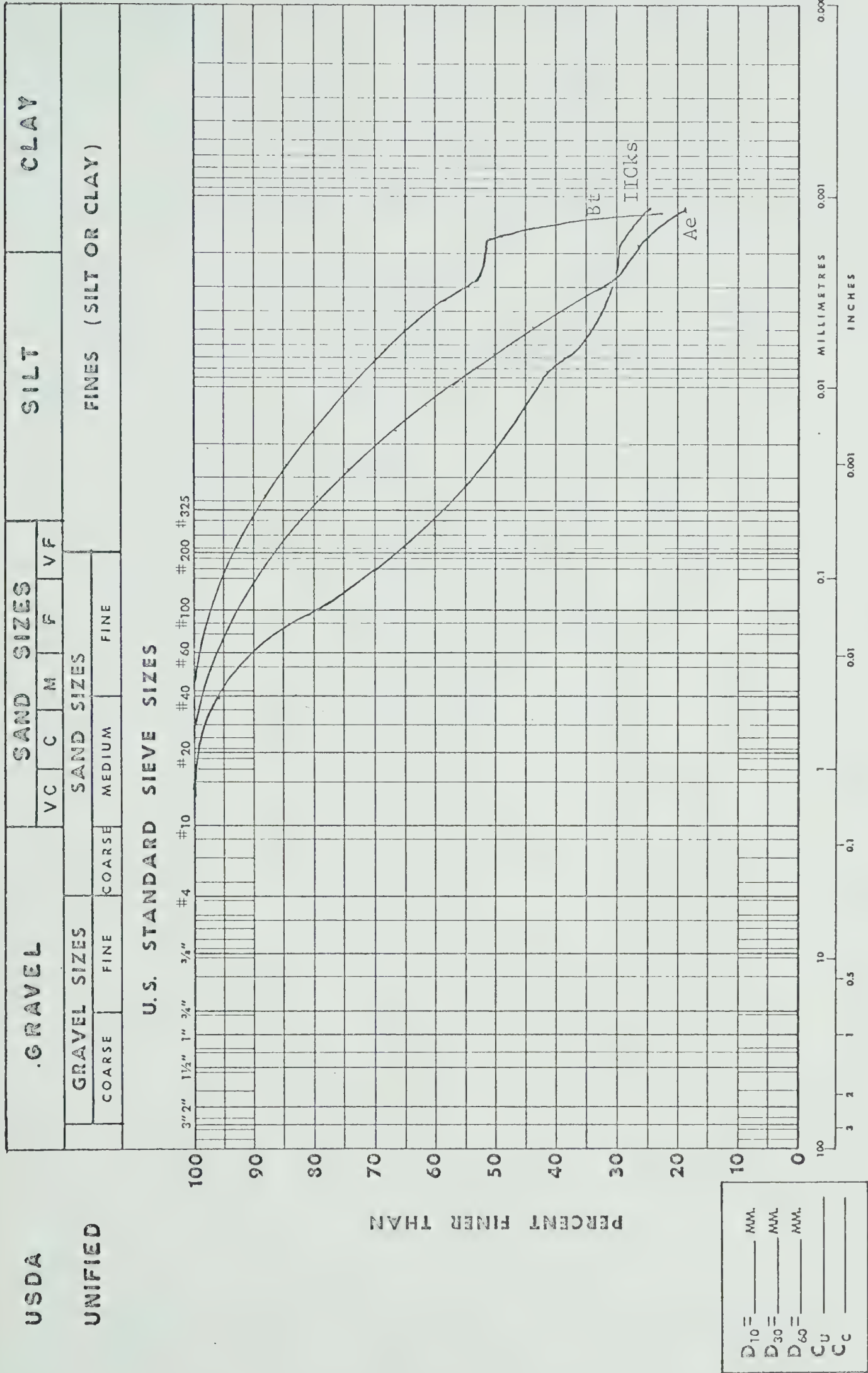
<u>HORIZON</u>	<u>DEPTH (cm.)</u>	<u>DESCRIPTION</u>
L-F	3-0	Very dark brown (7.5YR 2/2) when dry; partially and semi-decomposed leaf matter.
Ae	0-8	Dark grayish brown (10YR 4/2) when moist and grayish brown to light grayish brown (10YR 5.5/2) when dry; SiCL; strong medium platy; firm and slightly hard to hard; abundant fine and medium random roots; common very fine vesicular and interstitial pores; pH 5.5; clear smooth boundary; 5 to 13 cm. thick.
AB	8-13	Not sampled or described.
Bt	13-35	Black (10YR 2/1) exterior color when moist and very dark brown (10YR 2/2) when dry and dark yellowish brown (10YR 3/4) interior color when moist; SiC; moderate medium columnar macro-structure and strong fine sub-angular blocky meso-structure; firm and hard; plentiful fine vertical expd roots and plentiful medium horizontal expd roots; common very fine interstitial pores and few vesicular pores; common to many thin clay films on vertical ped surfaces and common thin clay films on horizontal ped surfaces; pH 6.1; clear smooth boundary; 17 to 22 cm. thick.
BC	35-68	Very dark grayish brown to dark brown (10YR 3/2.5) when moist and gray (5YR 5.5/1) when dry; CL; weak medium columnar macro-structure and moderate fine angular blocky meso-structure; firm and hard; plentiful fine and medium vertical expd roots; common very fine vesicular pores and many very fine interstitial pores; common thin clay films on vertical ped surfaces and few thin clay films on horizontal ped surfaces; pH 6.6; abrupt smooth boundary; 30 to 38 cm. thick.
II BCsk	68-98	Dark gray (10YR 4/1) exterior color when moist and light gray (10YR 7/1) when dry and dark yellowish brown (10YR 4/4) interior color when moist and yellowish brown (10YR 5/4) when dry with light gray (10YR 7/2) salt accumulations when moist and white (10YR 8/1) when dry; CL-C; weak fine angular blocky to massive; friable and hard; few fine vertical roots and very few medium vertical roots; few very fine vesicular and interstitial pores; few thin clay films on vertical ped surfaces; many fine and medium distinct salt accumulations; weakly effervescent; pH 7.0; clear wavy boundary; 25 to 35 cm. thick.
II BCcasa	98-128	Dark gray (10YR 4/1) exterior color when moist and gray to light gray (10YR 6.5/1) when dry and dark yellowish brown (10YR 4/4) interior color when moist and pale brown (10YR 6/3) when dry with white (10YR 8/2) salt and carbonate accumulations when moist and white (10YR 8/1) when dry; C; weak fine angular blocky to massive; friable and hard; few fine vertical expd roots; common very fine vesicular and interstitial pores; few thin clay films on vertical ped surfaces; many fine and medium distinct salt and carbonate accumulations; moderately effervescent; pH 7.4; clear smooth boundary; 25 to 28 cm. thick.
II Cks	128-181+	Dark gray to gray (10YR 4.5/1) when moist and gray to light gray (10YR 6.5/1) when dry and dark yellowish brown (10YR 4/4) when moist and pale brown (10YR 5.5/3) when dry with very pale brown (10YR 7/3) carbonate accumulations when moist and white (10YR 8/1) salt accumulations when moist; CL-C; massive; friable and hard; very few roots; few very fine vesicular pores; common fine distinct carbonate and salt accumulations; pH 7.5-7.7.



Profile Number M. 27

Horizon		Ae	Bt	BC	IIBCsk	IIBCcasa	IICks	IICks
Depth(cm)		0-8	13-35	35-68	68-98	98-128	128-155	155-181+
CHEMICAL ANALYSES								
pH		5.5	6.1	6.5	7.0	7.4	7.5	7.7
CaCO <sub>3</sub> Equiv.(%)		-	-	-	2.21	6.84	4.23	0.24
Org. C(%)		1.52	1.51	-	-	-	-	-
Exchange	H	-	4.18	1.59	0.46	0.04	-	-
Analysis	Ca	-	3.5	14.4	10.1	19.6	45.5	30.7
(meq/100 g)	Mg	-	5.9	14.2	10.5	11.1	11.1	11.5
	K	-	0.52	0.56	0.41	0.41	0.46	0.44
	Na	-	0.40	2.84	2.30	3.74	4.61	4.96
	TEC	-	14.8	34.0	22.6	21.6	20.5	18.4
Soluble	Ca	-	-	2.00	10.00	9.75	12.25	2.78
Salts	Mg	-	-	1.21	8.20	9.51	9.84	3.77
(meq/l)	Na	-	-	8.09	25.22	92.61	123.04	110.00
	SO <sub>4</sub>	-	-	19.38	77.38	97.30	97.30	46.88
EC(mmhos/cm)		-	-	1.60	5.60	6.75	7.00	3.90
PHYSICAL ANALYSES								
Particle	S	18	10	34	30	24	30	40
Size	Si	45	38	28	30	34	29	30
Analysis(%)	C	37	52	38	40	42	41	30
USDA Text. Class		SiCL	SiC	CL	CL-C	C	C	CL
Unified Rating		ML	CH	-	-	-	-	CL
Atterberg	LL	28	51	-	-	-	-	32
Limits(%)	PI	6	25	-	-	-	-	14
	LI	-	-	-	-	-	-	0.14
Bulk	Db	1.38	1.42	1.47	1.28	-	-	-
Density(g/cc)	%M	13	20	16	21	-	-	-
Penetrometer	Ave	1.8	1.7	-	-	-	-	1.9
(kg/cm <sup>2</sup> )	Rge	1.2-2.4	1.4-2.2	-	-	-	-	1.4-2.3
% Nat. M		24	26	-	-	-	-	20
% Hygro. M		1.83	4.57	2.63	2.83	2.80	2.32	1.69
% 15 bar M		10	20	14	14	15	14	12
% 1/3 bar M		27	36	28	30	32	30	26
% 1/10 bar M		-	-	-	-	-	-	-
% Sat. Cap.		-	-	53	54	59	55	55







Angstroms

3.32

7.0

10.0

14.0

17.0

Ae

Bt

IICks

30

28

26

24

22

20

18

16

14

12

10

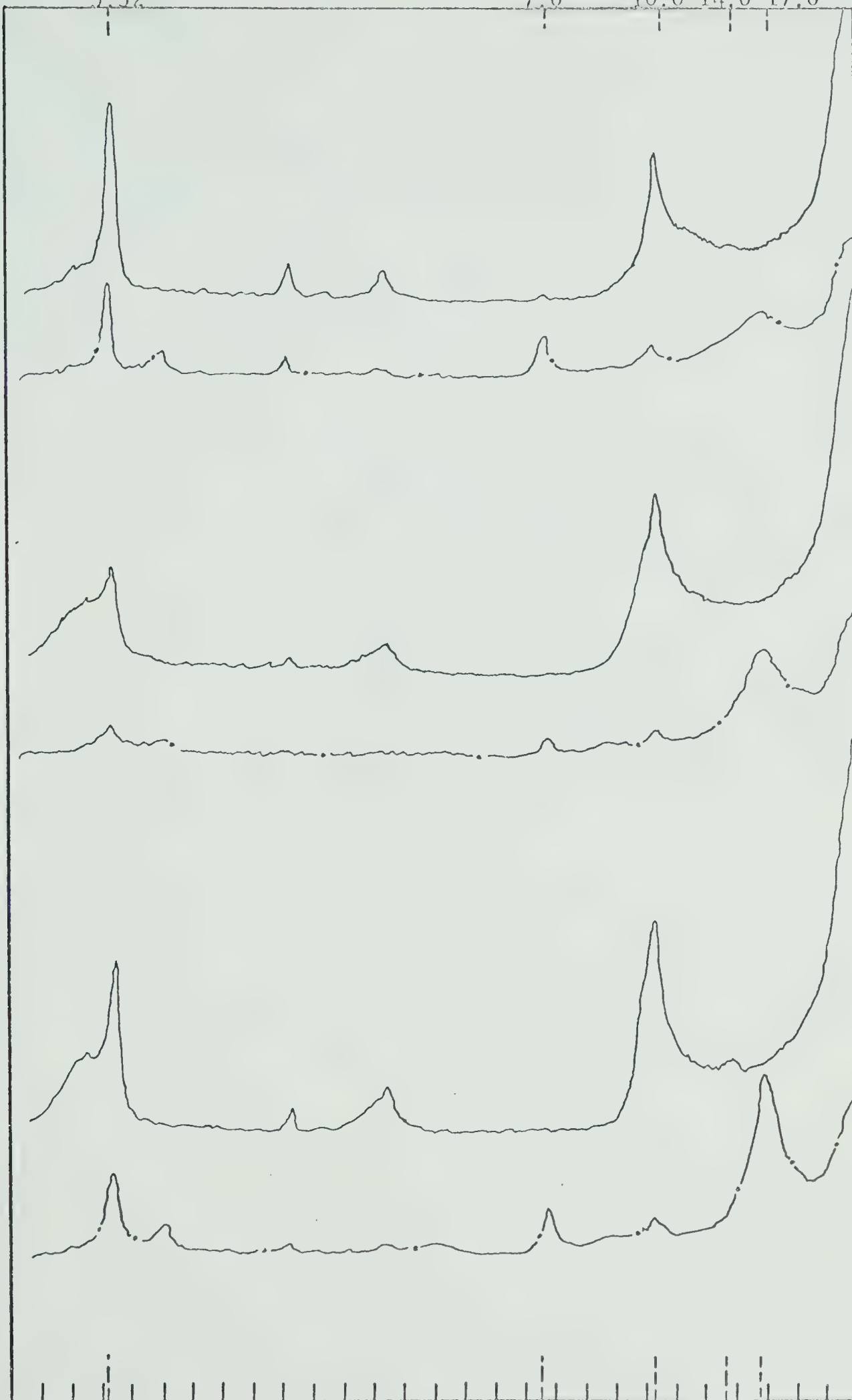
8

6

4

2

Degrees 2θ





Classification

Sub-group: Humic Gleysol

Series: Onoway

7th Approximation Equivalent: Typic Cryaquoll

Profile Number: M. 45

Parent Material: Brown colored till

Topography: c slope; SW aspect

Elevation above Lake Level: 7.3 metres

Drainage Class: Poor

Vegetation and Cover Estimates:

Tree Canopy: P. tremuloides (10%), P. balsamifera (10%),  
B. papyrifera (1%).

Shrubs: Salix spp. (5%), Rosa spp., C. stolonifera  
(1-5%), R. strigosus (1%), Ribes spp., L.  
involucrata, L. dioica.

Half-shrubs: C. canadensis, R. pubescens.

Herbs: A. millefolium, A. nudicanlis, A. conspicuus,  
E. angustifolium, F. virginiana, G. boreale,  
L. ochroleucus, M. paniculata, P. palmatus,  
P. asarifolia, S. amplexifolius, V. adunca.

Ferns: E. arvense.



<u>HORIZON</u>	<u>DEPTH (cm.)</u>	<u>DESCRIPTION</u>
L-H	3-0	Semi- and well decomposed leaf matter.
Ahej	0-13	Black (10YR 2/1) when moist and very dark brown (10YR 2/2) when dry; CL; weak, medium platy to fine granular; slightly plastic and friable; abundant fine, medium, and coarse random roots; common very fine vesicular pores; pH 6.4; clear, wavy boundary; 8 to 20 cm. thick.
Aejg	13-18	Discontinuous; not described or sampled.
Btjg	18-33	Dark gray (10YR 4/1) matrix color when moist and gray (10YR 5/1) matrix color when dry with dark reddish brown (5YR 3/4) mottles when moist and yellowish red (5YR 4/7) when dry; C; very fine blocky to shotty structure; plastic and firm; plentiful fine vertical roots and plentiful medium random roots; common very fine vesicular pores and many very fine interstitial pores; many fine and medium prominent mottles; pH 6.9; clear wavy boundary; 15 to 28 cm. thick.
BCgk <sub>1</sub>	33-65	Dark gray (10YR 4.5/1) matrix color when moist and gray (10YR 5.5/1) matrix color when dry with yellowish red (5YR 4/6) mottles when moist and yellowish red (5YR 4.5/6) when dry; CL; moderate very fine sub-angular blocky to shotty; plastic and friable; plentiful fine vertical roots and few medium roots; many very fine vesicular and interstitial pores; common fine prominent mottles; very weakly effervescent; pH 7.4; clear smooth boundary; 20 to 25 cm. thick.
BCgk <sub>2</sub>	65-88	Dark gray (10YR 4.5/1) matrix color when moist and gray (10YR 5.5/1) matrix color when dry with yellowish red (5YR 4/6) mottles when moist and yellowish red (5YR 4.5/6) when dry; CL; weak fine angular blocky; plastic and firm; few fine and medium roots; common very fine vesicular pores and many very fine interstitial pores; few fine prominent mottles; weakly effervescent; pH 7.6; abrupt smooth boundary; 20 to 28 cm. thick.
Ccag	88-101	Dark gray (10YR 4/1) matrix color when moist and gray to light gray (10YR 6.5/1) matrix color when dry with strong brown (7.5YR 4/6) mottles when moist and brownish yellow (10YR 6/6) mottles when dry; C; weak fine angular blocky to massive; plastic and firm; very few roots; common very fine vesicular pores and many very fine interstitial pores; common fine distinct mottles; common fine and medium distinct carbonate accumulations that are light gray (10YR 7/1) when moist and white (10YR 8/1) when dry; strongly effervescent; pH 7.5; clear smooth boundary; 10 to 20 cm. thick.
Ckg	101-165+	Dark gray (10YR 4/1) matrix color when moist and gray to light gray (10YR 6.5/1) matrix color when dry with strong brown (7.5YR 4/6) mottles when moist and brownish yellow (10YR 6/6) mottles when dry; CL-SCL; weak fine angular blocky to massive; plastic and firm; very few roots; common very fine vesicular pores and many very fine interstitial pores; common fine distinct mottles; few faint carbonate accumulations; moderately effervescent; pH 7.4.



Profile Number M. 45

Horizon	Ahej	Btjg	BCgk <sub>1</sub>	BCgk <sub>2</sub>	Ccag	Ckg
Depth(cm)	0-13	18-33	33-65	65-88	88-101	101-165+

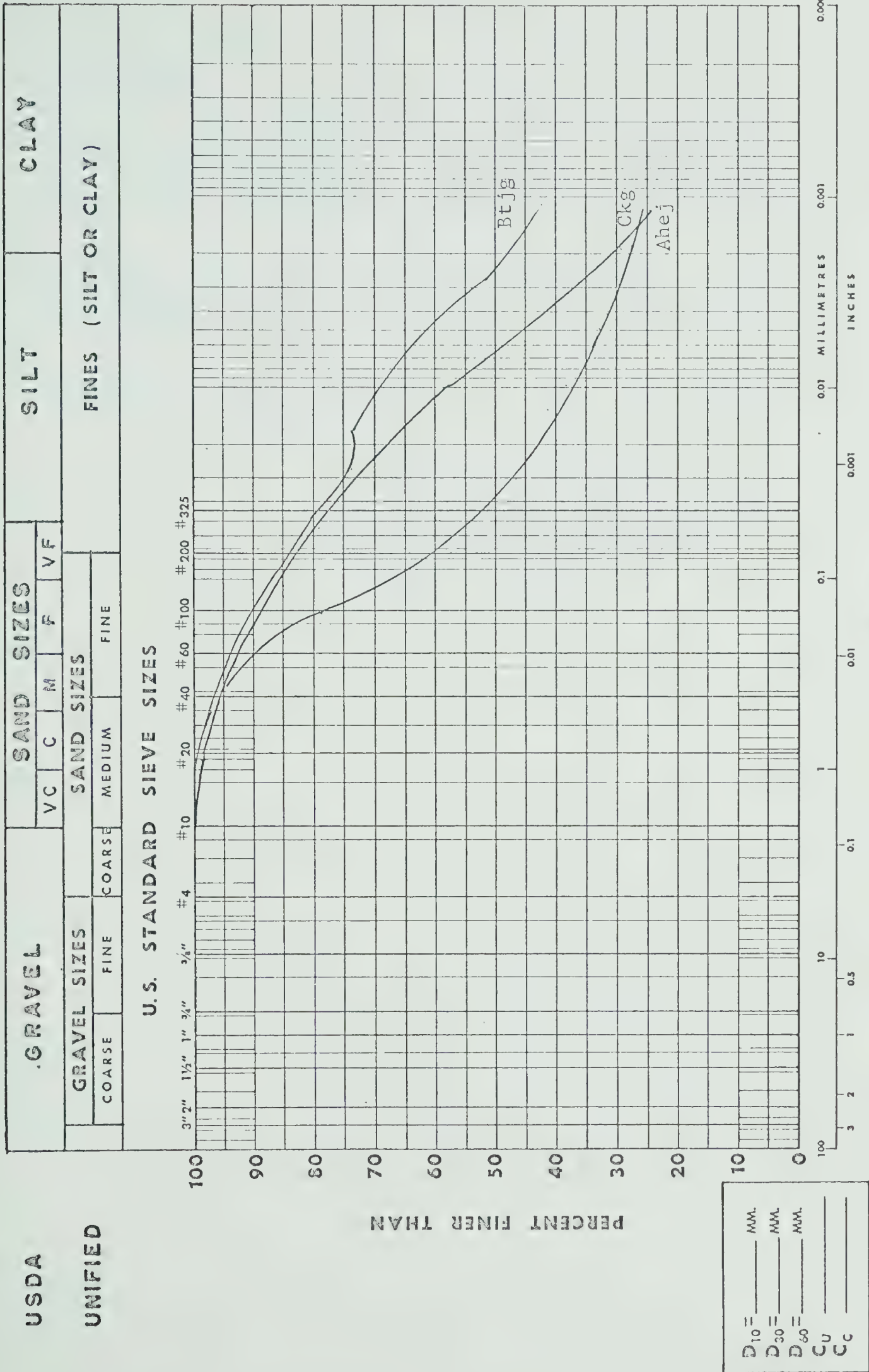
## CHEMICAL ANALYSES

pH		6.4	6.9	7.4	7.6	7.5	7.4
CaCO <sub>3</sub> Equiv.(%)		-	-	0.23	0.23	4.50	4.02
Org. C(%)		4.49	1.17	-	-	-	-
Exchange	H	5.32	1.39	-	-	-	-
Analysis	Ca	17.3	19.1	11.9	-	32.9	25.7
(meq/100 g)	Mg	14.2	15.5	9.2	-	14.9	8.9
	K	0.48	0.54	0.50	-	0.66	0.49
	Na	0.69	0.75	0.77	-	2.57	1.35
	TEC	36.2	35.0	22.0	-	25.0	15.2
Soluble	Ca	-	-	-	2.38	9.50	13.25
Salts	Mg	-	-	-	1.62	7.87	7.87
(meq/l)	Na	-	-	-	44.78	70.87	78.26
	SO <sub>4</sub>	-	-	-	21.09	57.50	58.44
EC(mmhos/cm)		-	-	-	2.15	4.40	4.20

## PHYSICAL ANALYSES

Particle	S	22	20	38	39	18	47
Size	Si	48	32	27	29	30	25
Analysis(%)	C	30	48	35	32	52	28
USDA Text. Class		CL	C	CL	CL	C	CL-SCL
Unified Rating		MH	MH	-	-	-	CL
Atterberg	LL	55	53	-	-	-	33
Limits(%)	PI	14	20	-	-	-	17
	LI	0.07	0.10	-	-	-	0.06
Bulk	Db	0.86	1.02	-	1.37	-	1.70
Density(g/cc)	%M	42	35	-	24	-	15
Penetrometer	Ave	-	-	-	-	-	-
(kg/cm <sup>2</sup> )	Rge	-	-	-	-	-	-
% Nat. M		-	-	-	-	-	-
% Hygro. M		4.82	4.41	2.87	2.61	3.76	1.86
% 15 bar M		8	12	7	7	10	7
% 1/3 bar M		47	37	26	30	41	27
% 1/10 bar M		-	-	-	-	-	-
% Sat. Cap.		-	-	-	46	67	48







Classification

Sub-group: Humic Gleysol  
Series: Raven (Rv)  
7th Approximation Equivalent: Typic Cryaquoll  
Profile Number: M. 63

Parent Material: Lacustrine clay  
Topography: b slope  
Elevation above Lake Level: 3 metres  
Drainage Class: Poor

Vegetation and Cover Estimates:

Tree Canopy:

Shrubs: Rosa spp.

Herbs: A. millefolium, A. nudicaulis, A. conspicuous, Aster spp., A. syriaca, C. album L., C. arvense (L.) Scap.

Grasses: H. jubatum, F. scabrella.



<u>HORIZON</u>	<u>DEPTH (cm.)</u>	<u>DESCRIPTION</u>
L-F	2-0	Partially decomposed grass matter.
Ahg <sub>1</sub>	0-15	Very dark grayish brown (10YR 3/2) matrix color when moist and dark grayish brown (10YR 4/2) when dry with yellowish red (5YR 3/6) mottles when moist and yellowish red (5YR 4.5/7) when dry; SiC; weak fine granular (shotty); slightly sticky, slightly plastic, friable, and slightly hard; abundant fine vertical roots and few medium vertical roots; many very fine interstitial pores; few fine prominent mottles; pH 7.1; abrupt smooth boundary; 10 to 18 cm. thick.
Ahg <sub>2</sub>	15-25	Dark brown (10YR 3.5/3) matrix color when moist and grayish brown (10YR 5/1.5) when dry with yellowish red (5YR 4/6) mottles when moist and yellowish red (5YR 5/7) when dry; SiC-C; weak fine granular (shotty); very friable and slightly hard; plentiful fine vertical roots; many very fine interstitial pores; few fine prominent mottles; pH 4.9; abrupt smooth boundary; 7 to 13 cm. thick.
Ahg <sub>3</sub>	25-30	Very dark brown (10YR 2/3) when moist and dark grayish brown to dark brown (10YR 4/2.5) when dry; SiC-C; amorphous; friable and slightly hard; plentiful fine vertical roots; few very fine vesicular pores; common fine faint mottles; pH 4.8; abrupt wavy boundary; 2 to 10 cm. thick.
Ahg <sub>4</sub>	30-37	Very dark brown (10YR 2/2) matrix color when moist and very dark gray (10YR 3/1) when dry with strong brown (7.5YR 4/6) mottles when moist; SiC; weak fine granular; slightly plastic, friable, and slightly hard; plentiful fine vertical roots; many very fine interstitial pores; common fine distinct mottles; pH 4.4; clear wavy boundary; 2 to 7 cm. thick.
Bg	37-47	Very dark gray (10YR 3/1) matrix color when moist and gray (10YR 5.5/1) when dry with yellowish red (5YR 4/6) mottles when moist and yellowish red (5YR 4/7) when dry; SiC; moderate fine sub-angular blocky; plastic, firm, and hard; few fine vertical roots; many very fine interstitial pores; common fine prominent mottles; pH 4.6; clear smooth boundary; 7 to 13 cm. thick.
BCgk <sub>1</sub>	47-57	Very dark gray to dark gray (10YR 3.5/1) matrix color when moist and gray (10YR 5.5/1) when dry with strong brown (7.5YR 4/6) mottles when moist and strong brown (7.5YR 5/6) when dry; SiC-C; moderate fine angular blocky; very plastic, firm, and very hard; few fine vertical roots; many very fine interstitial pores; few fine distinct mottles; very weakly effervescent; pH 6.6; clear wavy boundary; 5 to 13 cm. thick.
BCgk <sub>2</sub>	57-82	Dark gray (10YR 4/1) matrix color when moist and gray (10YR 5.5/1) when moist with yellowish red (5YR 4/8) mottles when moist and yellowish red (5YR 5/7) when dry; C; moderately strong fine angular blocky; plastic, firm, and very hard; few fine vertical roots; many very fine interstitial pores; common faint and prominent fine and medium mottles; weakly effervescent; pH 7.4; clear smooth boundary; 22 to 27 cm. thick.
Ckg	82-175+	Dark gray (10YR 4/1) matrix color when moist and gray (10YR 6/1) when dry with yellowish brown (10YR 5/6) mottles when moist and brownish yellow (10YR 6/6) when dry and very pale brown (10YR 8/3) carbonate accumulations when moist and white (10YR 8/1) when dry; CL-SCL; moderate fine angular blocky; plastic, firm, and hard; few fine vertical roots; many very fine vesicular and interstitial pores; common fine and medium faint mottles; few medium distinct carbonate accumulations; moderately effervescent; pH 7.6.



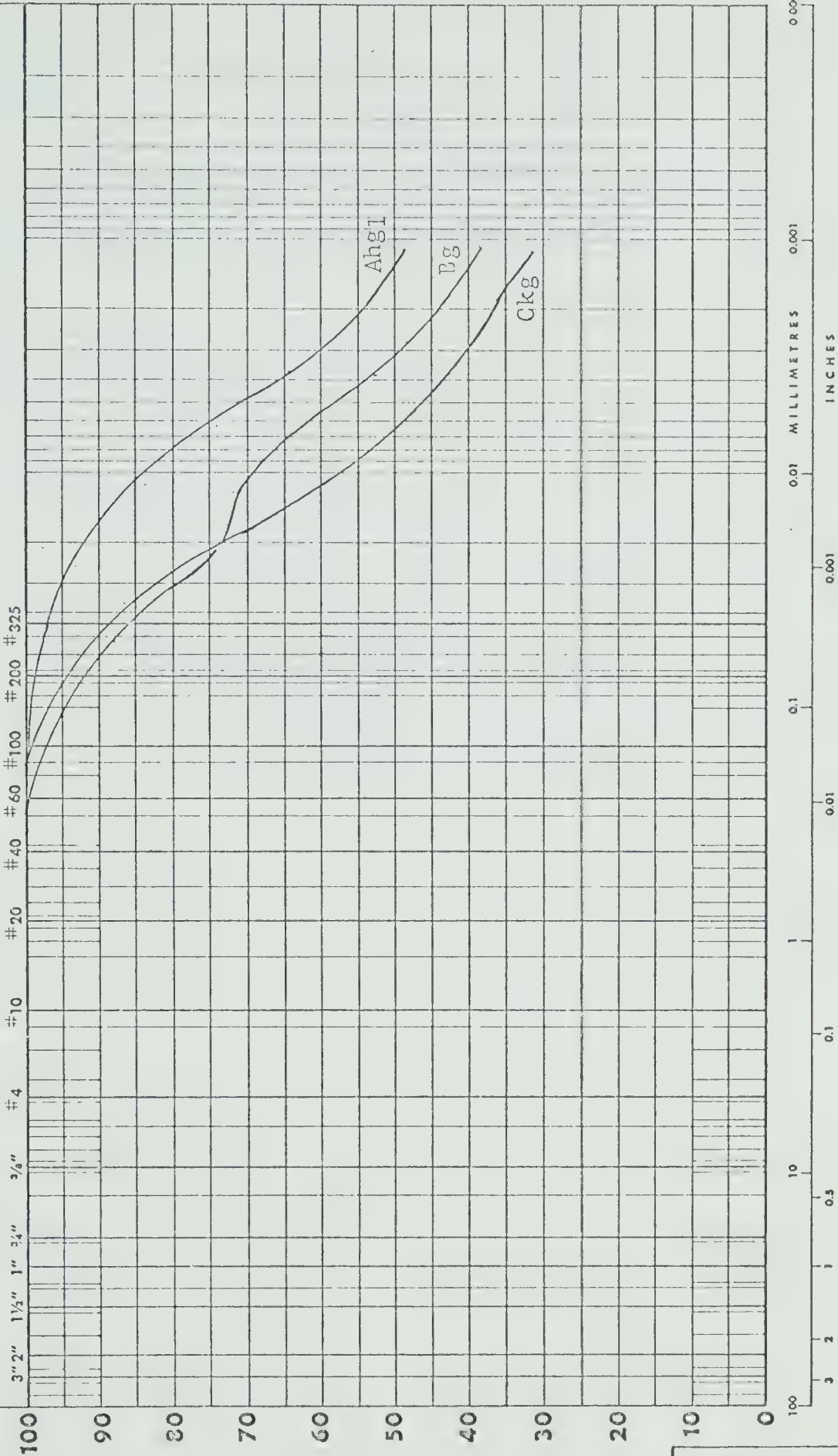
Profile Number M. 63

Horizon		Ahg <sub>1</sub>	Ahg <sub>2</sub>	Ahg <sub>3</sub>	Ahg <sub>4</sub>	Bg	BCgk <sub>1</sub>	BCgk <sub>2</sub>	Ckg
Depth(cm)		0-15	15-25	25-30	30-37	37-47	47-57	57-82	82-175+
CHEMICAL ANALYSES									
pH		7.1	4.0	3.9	4.0	4.5	6.6	7.4	7.5
CaCO <sub>3</sub> Equiv.(%)		2.66	-	-	-	-	-	1.49	3.09
Org. C(%)		6.01	4.56	7.00	4.84	1.71	-	-	-
Exchange	H	-	10.07	12.55	16.07	4.80	0.15	-	-
Analysis	Ca	36.0	25.2	32.1	13.6	16.3	16.1	13.1	-
(meq/100 g)	Mg	13.0	18.0	10.4	13.5	13.7	20.9	18.1	-
	K	1.11	1.03	1.00	1.46	1.27	1.58	1.27	-
	Na	1.02	1.89	2.47	3.06	3.12	4.75	4.96	-
	TEC	37.5	33.8	35.4	35.8	27.6	35.0	31.7	-
Soluble	Ca	-	-	-	9.50	10.75	10.25	2.38	5.85
Salts	Mg	-	-	-	22.62	20.98	19.34	3.77	5.74
(meq/l)	Na	-	-	-	184.78	23.05	100.00	17.39	21.74
	SO <sub>4</sub>	-	-	-	118.63	106.14	100.21	42.19	34.38
EC(mmhos/cm)		-	-	-	7.25	6.90	6.75	3.60	4.10
PHYSICAL ANALYSES									
Particle	S	5	8	14	12	14	6	8	10
Size	Si	40	36	38	46	42	36	34	46
Analysis(%)	C	55	56	48	42	44	58	58	44
USDA Text. Class		SiC	SiC-C	SiC-C	SiC	SiC	SiC-C	C	SiC
Unified Rating		MH	-	-	-	ML	-	-	CL
Atterberg	LL	71	-	-	-	44	-	-	47
Limits(%)	PI	18	-	-	-	16	-	-	26
	LI	0.06	-	-	-	-0.17	-	-	-
Bulk	Db	0.86	0.93	-	-	1.35	-	1.49	-
Density(g/cc)	%M	54	28	-	-	24	-	25	-
Penetrometer	Ave	-	-	-	-	-	-	-	-
(kg/cm <sup>2</sup> )	Rge	-	-	-	-	-	-	-	-
% Nat. M		-	-	-	-	-	-	-	-
% Hygro. M		5.36	4.91	4.79	4.36	2.63	4.85	3.72	2.28
% 15 bar M		14	10	24	20	17	21	22	15
% 1/3 bar M		43	41	44	41	31	39	39	36
% 1/10 bar M		-	-	-	-	-	-	-	-
% Sat. Cap.		-	-	-	58	55	76	86	77



USDA  UNIFIED	GRAVEL		SAND SIZES					SILT	CLAY
			VC	C	M	F	VF		
	GRAVEL SIZES		SAND SIZES					FINES (SILT OR CLAY)	
	COARSE	FINE	COARSE	MEDIUM	FINE				

U.S. STANDARD SIEVE SIZES





Classification

Sub-group: Saline Low Humic Eluviated Gleysol  
Series: Westwind (Ww)  
7th Approximation Equivalent: Salic Albaqualf  
Profile Number: M. 74

Parent Material: Lacustrine clay  
Topography: b slope  
Elevation above Lake Level: 4 metres  
Drainage Class: Poor

Vegetation and Cover Estimates:

Tree Canopy: P. tremuloides (5%), P. balsamifera (10%).  
Shrubs: Salix spp. (5%), Rosa spp., C. stolonifera  
(1-5%), S. albus (1%), Ribes spp., L. dioica.  
Half-shrubs: R. pubescens.  
Herbs: A. millefolium, A. conspicuus, Aster spp.,  
E. angustifolium, F. virginiana, G. trifolium,  
M. paniculata, V. americana, V. adunca.  
Grasses: F. scabrella.



<u>HORIZON</u>	<u>DEPTH (cm.)</u>	<u>DESCRIPTION</u>
L-H	3-0	Very dark brown (7.5YR 2/2) when dry; semi- and well decomposed leaf matter.
Aeg	0-8	Very dark gray (10YR 3/1) matrix color when moist and dark grayish brown (10YR 4/2) when dry with strong brown (7.5YR 4/6) mottles when moist and strong brown (7.5YR 5/6) when dry; SiCL-SiC; moderate fine platy; friable and slightly hard; plentiful fine vertical roots and abundant medium horizontal roots; many very fine interstitial pores and few very fine vesicular pores; pH 5.8; clear smooth boundary; 5 to 10 cm. thick.
ABg	8-13	Discontinuous; not described or sampled.
Btg	13-25	Very dark gray to black (10YR 2.5/1) matrix color when moist and gray (10YR 5.5/1) when dry with yellowish red (5YR 3.5/6) mottles when moist and yellowish red (5YR 4/7) when dry; SiC; moderate medium prismatic macro-structure and moderate fine angular blocky meso-structure; firm and very hard; plentiful fine vertical roots and abundant medium horizontal roots; common very fine vesicular pores and many very fine interstitial pores; common thin clay films on vertical ped surfaces; common fine prominent mottles; pH 6.2; clear smooth boundary; 10 to 15 cm. thick.
BCgk	25-45	Dark gray (10YR 4/1) matrix color when moist and gray (10YR 5/1) when dry with yellowish red (5YR 3/7) mottles when moist and bright brown (7.5YR 5/6) when dry; SiC-C; weak medium prismatic macro-structure and moderately strong fine angular blocky meso-structure; firm and very hard; few fine vertical roots and plentiful medium random roots; many very fine vesicular and interstitial pores; few thin clay films on vertical ped surfaces; many fine prominent mottles; very weakly effervescent; pH 7.3; clear smooth boundary; 17 to 23 cm. thick.
Ccag	45-75	Dark gray (10YR 4/1) matrix color when moist and gray to light gray (10YR 6.5/1) when dry with strong brown (7.5YR 5/6) mottles when moist and yellowish brown (10YR 5.5/6) when dry and light gray (10YR 7/2) carbonate accumulations when moist and white (10YR 8/1) when dry; SiC; moderate fine angular blocky; firm and hard; few fine and medium vertical roots; many very fine vesicular and interstitial pores; common fine distinct mottles; common fine and medium distinct carbonate accumulations; weak to moderately effervescent; pH 7.6; clear smooth boundary; 25 to 35 cm. thick.
Ckg <sub>1</sub>	75-93	Dark gray (10YR 4/1) matrix color when moist and gray (10YR 6/1) when dry with dark yellowish brown (10YR 4/6) mottles when moist and yellowish brown (10YR 5.5/6) when dry; SiC; moderate fine angular blocky; firm and hard; few fine vertical roots and very few medium vertical roots; many fine faint mottles; weak to moderately effervescent; pH 7.3; clear wavy boundary; 15 to 27 cm. thick.
Ckg <sub>2</sub>	97-175+	Dark gray (10YR 4/1) matrix color when moist and gray to light gray (10YR 6.5/1) when dry with dark yellowish brown (10YR 4/6) mottles when moist and light yellowish brown (10YR 6/4) when dry and light gray (10YR 7/2) carbonate accumulations when moist and white (10YR 8/1) when dry; SiCL-SiC; moderate fine medium blocky; firm and hard; very few roots; few very fine vesicular pores and many very fine interstitial pores; many fine faint mottles; common fine and medium carbonate accumulations; moderately effervescent; pH 7.6-7.8.



Profile Number M. 74

Horizon		Aeg	Btg	BCgk	Ccag	Ckg <sub>1</sub>	Ckg <sub>2</sub>	Ckg <sub>2</sub>
Depth(cm)		0-8	13-25	25-45	45-75	75-93	97-135	135-175+
CHEMICAL ANALYSES								
pH		5.8	6.2	7.3	7.6	7.3	7.8	7.6
CaCO <sub>3</sub> Equiv.(%)		-	-	0.06	1.37	4.06	10.63	6.98
Org. C(%)		5.35	1.46	-	-	-	-	-
Exchange	H	5.38	1.63	-	-	-	-	-
Analysis	Ca	11.1	8.9	9.7	-	-	-	-
(meq/100 g)	Mg	10.5	13.7	15.7	-	-	-	-
	K	1.27	1.24	1.19	-	-	-	-
	Na	0.27	0.99	2.52	-	-	-	-
	TEC	30.3	25.5	28.7	-	-	-	-
Soluble	Ca	1.10	0.95	1.00	9.13	6.20	10.25	8.75
Salts	Mg	1.01	1.01	1.42	13.93	11.15	18.03	12.30
(meq/l)	Na	0.92	2.87	25.48	66.52	369.57	92.61	83.91
	SO <sub>4</sub>	3.52	4.89	13.91	98.34	98.34	111.87	88.45
EC(mmhos/cm)		0.75	0.83	1.60	7.00	7.00	7.5	6.3
PHYSICAL ANALYSES								
Particle	S	13	9	7	2	7	-	18
Size	Si	47	50	41	44	52	-	43
Analysis(%)	C	40	41	52	54	41	-	39
USDA Text. Class		SiCL-SiC	SiC	SiC-C	SiC	SiC	-	SiCL-SiC
Unified Rating		ML-MH	CL	-	-	-	-	CL
Atterberg	LL	50	40	-	-	-	-	40
Limits(%)	PI	11	19	-	-	-	-	16
	LI	-1.70	-0.21	-	-	-	-	-
Bulk	Db	1.05	1.29	1.38	1.34	-	-	-
Density(g/cc)	%M	20	17	20	21	-	-	-
Penetrometer	Ave	-	-	-	-	-	-	-
(kg/cm <sup>2</sup> )	Rge	-	-	-	-	-	-	-
% Nat. M		-	-	-	-	-	-	-
% Hygro. M		2.05	2.50	3.61	4.20	2.51	7.59	2.46
% 15 bar M		21	15	20	21	17	20	17
% 1/3 bar M		36	30	36	40	36	43	35
% 1/10 bar M		-	-	-	-	-	-	-
% Sat. Cap.		65	51	76	84	69	80	61







Classification

Sub-group: Saline Rego Gleysol

Series: Wanisan 3 (W<sub>1</sub>3)

7th Approximation Equivalent: Salic Psammentic Cryaquept

Profile Number: M. 48

Parent Material: Beach sand / clay till

Topography: c slope; N aspect

Elevation above Lake Level: 3 metres

Drainage Class: Poor

Vegetation and Cover Estimates:

Tree Canopy: P. tremuloides (1-5%), P. balsamifera (5%).

Shrubs: Salix spp. (5%), S. canadensis (5%).

Half-shrubs: R. pubescens.

Herbs: A. millefolium, A. conspicuous, F. virginiana,  
G. trifolium, P. asarifolia, V. americana,  
A. syriaca, C. album L.

Grasses: F. scabrella.



<u>HORIZON</u>	<u>DEPTH (cm.)</u>	<u>DESCRIPTION</u>
L-H	2-0	Semi-decomposed leaf and grass matter.
C	0-10	Light brownish gray to pale brown (10YR 6/2.5) coarse beach sand; single grain; loose; abundant fine, medium and coarse random roots; pH 6.6; abrupt smooth boundary; 7 to 13 cm. thick.
Cgk	10-35	Light brownish gray (10YR 6/2) matrix color when moist and gray to light gray (10YR 6.5/1) when dry with strong brown (7.5YR 5/8) mottles when moist and strong brown (7.5YR 5/7) when dry; S; single grain; very friable and loose; abundant fine vertical roots and abundant medium and coarse random roots; common fine and medium distinct mottles; very weakly effervescent; pH 6.5; gradual smooth boundary; 22 to 30 cm. thick.
	35-40	Contact zone between sand and underlying glacial till.
II Ccags	40-78	Dark gray (10YR 4/1) matrix color when moist and gray (10YR 6/1) when dry with yellowish brown (10YR 5/6) mottles when moist and brownish yellow (10YR 6/5) when dry; HC; massive; plastic, firm, and hard; few fine vertical roots and plentiful medium horizontal and vertical roots; common very fine vesicular pores; many fine distinct mottles; weakly effervescent; pH 7.4; clear smooth boundary; 32 to 38 cm. thick.
II Ckgs	78-130	Dark gray (10YR 4/1) matrix color when moist and gray (10YR 4.5/1 and 10YR 6/1) when dry with yellowish brown (10YR 5/6) mottles when moist and yellowish brown to brownish yellow (10YR 5.5/6) when dry and light gray (10YR 7/2) carbonate accumulations; HC; weak fine angular blocky to massive; plastic, firm, and hard; few fine vertical roots; few very fine vesicular pores and common very fine interstitial pores; common fine faint mottles; common fine and medium distinct carbonate accumulations; moderately effervescent; pH 7.6; abrupt smooth boundary; 47 to 55 cm. thick.
II Ckgs	130-175+	Dark gray (10YR 4/1) matrix color when moist and gray (10YR 4.5/1 and 10YR 6/1) when dry with yellowish brown (10YR 5/6) mottles when moist and yellowish brown to brownish yellow (10YR 5.5/6) when dry and light gray (10YR 7/2) carbonate accumulations; CL; massive; plastic, firm, and hard; common fine faint mottles; few fine distinct salt and carbonate accumulations; weakly effervescent; pH 7.5.



Profile Number M. 48

Horizon	C	Cgk	IICgca	IICgks	IICgks
Depth(cm)	0-10	10-35	40-78	78-130	130-175+

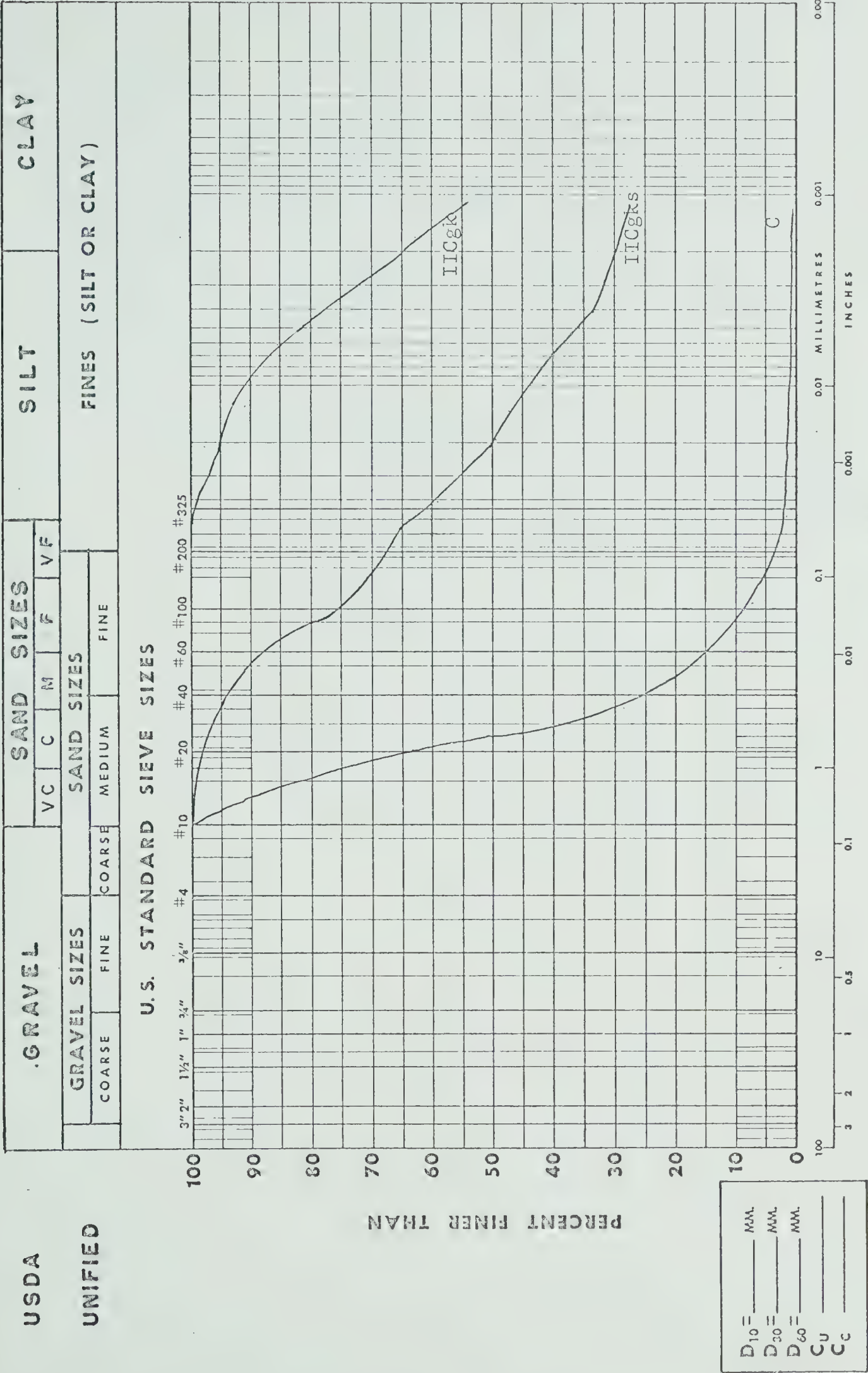
## CHEMICAL ANALYSES

pH		6.6	6.5	7.4	7.6	7.5
CaCO <sub>3</sub> Equiv.(%)		-	-	9.35	3.61	3.42
Org. C(%)		-	-	-	-	-
Exchange	H	0.39	0.39	-	-	-
Analysis	Ca	0.5	1.5	29.0	-	21.0
(meq/100 g)	Mg	0.9	1.1	14.4	-	8.3
	K	0.11	0.09	0.87	-	0.50
	Na	0.01	0.01	2.25	-	1.35
	TEC	1.1	1.7	27.0	-	14.6
Soluble	Ca	1.08	0.58	3.95	8.63	11.00
Salts	Mg	0.35	0.20	3.28	6.56	7.38
(meq/l)	Na	3.39	3.39	116.52	106.52	321.74
	SO <sub>4</sub>	0.20	0.20	30.88	61.75	65.63
EC(mmhos/cm)		0.3	0.2	3.0	5.0	5.0

## PHYSICAL ANALYSES

Particle	S	98	91	0	4	38
Size	Si	1	6	35	28	32
Analysis(%)	C	1	3	65	68	30
USDA Text. Class		S	S	HC	HC	CL
Unified Rating		SP	-	CH	-	CL
Atterberg	LL	-	-	69	-	32
Limits(%)	PI	-	-	41	-	16
	LI	-	-	-	-	-
Bulk	Db	-	-	-	-	-
Density(g/cc)	%M	-	-	-	-	-
Penetrometer	Ave	-	-	-	-	-
(kg/cm <sup>2</sup> )	Rge	-	-	-	-	-
% Nat.M		-	-	-	-	-
% Hygro. M		0.09	0.13	4.00	4.20	1.80
% 15 bar M		1	2	25	33	15
% 1/3 bar M		1	2	37	47	26
% 1/10 bar M		-	-	-	-	-
% Sat. Cap.		21	24	70	79	48







Classification

Sub-group: Saline Rego Gleysol

Series: Wanisan 2 (W12)

7th Approximation Equivalent: Salic Psammentic Cryaquept

Profile Number: M. 50

Parent Material: Beach sand / brown colored till

Topography: b slope; N aspect

Elevation above Lake Level: 4.5 metres

Drainage Class: Poor

Vegetation and Cover Estimates:

Tree Canopy: P. tremuloides (1%), P. balsamifera (1-5%).

Shrubs: Salix spp. (5%), S. canadensis (5%).

Herbs: A. millefolium, A. conspicuous, Aster spp.,  
F. virginiana, G. trifolium, P. asarifolia.

Grasses: F. scabrella.



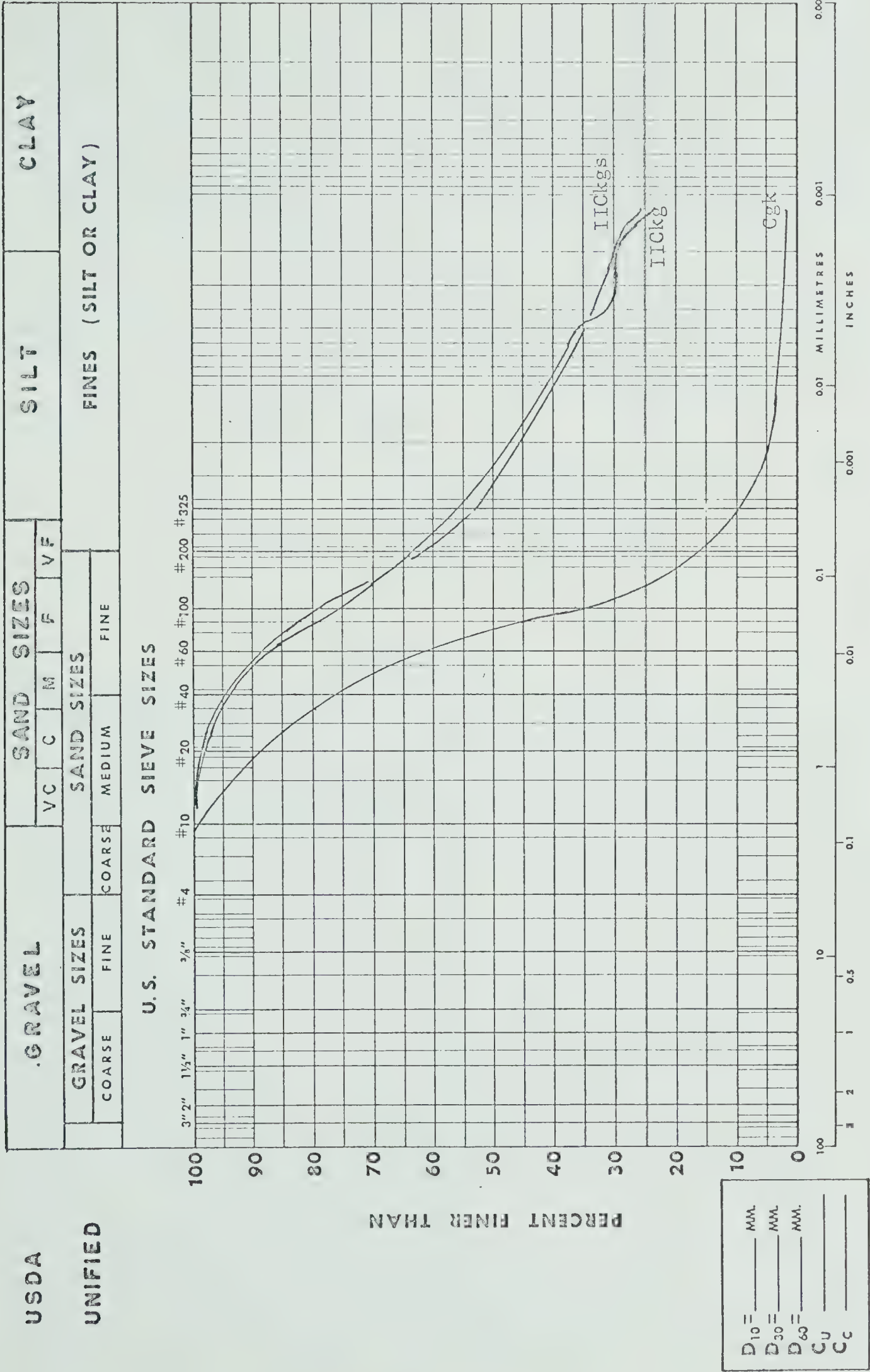
<u>HORIZON</u>	<u>DEPTH (cm.)</u>	<u>DESCRIPTION</u>
L-H	2-0	Semi-decomposed leaf and grass matter.
Cgk	0-10	Light brownish gray (10YR 6/2) when dry with yellowish brown (10YR 5/6) mottles when dry; LS; single grain; very friable and loose; abundant fine vertical roots and abundant horizontal medium roots; many fine distinct mottles; very weakly effervescent; pH 7.6; abrupt smooth boundary; 8 to 12 cm. thick.
II Cgk	10-28	Dark grayish brown (10YR 4/2) matrix color when moist and gray (10YR 5/1) when dry with yellowish red (5YR 4/6) mottles when moist and yellowish red (5YR 4/7) when dry and light gray (10YR 7/2) carbonate accumulations; CL; massive; firm and hard; plentiful fine vertical roots and abundant medium random roots; common very fine vesicular pores; many fine and medium prominent mottles; common fine distinct carbonate accumulations; moderately effervescent; pH 7.5; clear wavy boundary; 13 to 23 cm. thick.
II Cgca	28-43	Dark grayish brown (10YR 4/2) matrix color when moist and light brownish gray (10YR 6/2) when dry with yellowish red (5YR 4/6) mottles when moist and yellowish red (5YR 4.5/7) when dry and light gray (10YR 7/2) carbonate accumulations; CL-L; massive; firm and hard; few fine and medium random roots; common very fine vesicular pores; common fine prominent mottles; many medium distinct carbonate accumulations; strongly effervescent; pH 7.8; clear wavy boundary; 8 to 20 cm. thick.
II Ckg	43-93	Dark gray to gray (10YR 4.5/1) matrix color when moist and gray (10YR 5.5/1) when dry with dark yellowish brown (10YR 3/4) mottles when moist and strong brown (7.5YR 4.5/6) when dry and light gray (10YR 7/2) carbonate accumulations; CL-L; weak fine angular blocky to massive; friable and hard; few roots; few vesicular and interstitial pores; common fine and medium distinct mottles; few fine distinct carbonate accumulations; weak to moderately effervescent; pH 7.4; clear wavy boundary; 35 to 55 cm. thick.
II Ckgs	93-175+	Dark gray to gray (10YR 4.5/1) matrix color when moist and gray (10YR 5.5/1) when dry with dark yellowish brown (10YR 3/4) mottles when moist and strong brown (7.5YR 4.5/6) when dry and light gray (10YR 7/2) salt and carbonate accumulations; CL; massive; friable and hard; very few roots; few vesicular pores; common fine and medium distinct mottles; common fine distinct salt and carbonate accumulations; weak to moderately effervescent; pH 7.5-7.7; pockets of lacustrine clay within.



Profile Number M. 50

Horizon		Cgk	IICgk	IICgca	IICkg	IICksg	IICksg.
Depth(cm)		0-10	10-28	28-43	43-93	93-130	130-175+
CHEMICAL ANALYSES							
pH		7.5	7.5	7.8	7.4	7.5	7.7
CaCO <sub>3</sub> Equiv.(%)		0.46	5.24	6.24	4.71	3.58	4.01
Org. C(%)		-	-	-	-	-	-
Exchange	H	-	-	-	-	-	-
Analysis	Ca	18.8	-	50.5	-	18.6	27.5
(meq/100 g)	Mg	10.0	-	7.8	-	9.2	8.5
	K	0.77	-	0.70	-	0.49	0.36
	Na	2.93	-	1.02	-	2.11	2.17
	TEC	19.5	-	12.9	-	12.7	13.4
Soluble	Ca	1.95	11.25	4.13	9.13	10.50	5.98
Salts	Mg	1.15	11.48	7.05	12.79	11.97	7.38
(meq/l)	Na	1.18	17.39	21.74	26.09	25.22	19.57
	SO <sub>4</sub>	3.28	73.13	55.50	85.85	84.06	57.06
EC(mmhos/cm)		0.85	4.90	4.30	6.00	5.50	4.25
PHYSICAL ANALYSES							
Particle	S	89	46	41	47	46	43
Size	Si	8	25	31	25	25	27
Analysis(%)	C	3	29	28	28	29	30
USDA Text. Class		LS	CL	CL-L	CL-L	CL	CL
Unified Rating		SW-SC	CL	-	-	-	CL
Atterberg	LL	-	32	-	-	-	33
Limits(%)	PI	-	19	-	-	-	19
	LI	-	-	-	-	-	-
Bulk	Db	-	-	-	-	-	-
Density(g/cc)	%M	-	-	-	-	-	-
Penetrometer	Ave	-	-	-	-	-	-
(kg/cm <sup>2</sup> )	Rge	-	-	-	-	-	-
% Nat. M		-	-	-	-	-	-
% Hygro. M		0.32	2.22	1.48	1.53	1.66	1.71
% 15' bar M		4	11	11	11	11	13
% 1/3 bar M		5	24	25	23	25	26
% 1/10 bar M		-	-	-	-	-	-
% Sat. Cap.		30	46	44	48	47	50







## APPENDIX AII

Morphological and Analytical Characteristics of the Soils  
at Sir Winston Churchill Provincial Park



Classification

Sub-group: Orthic Gray Luvisol  
Series: Grandin (Gn)  
7th Approximation Equivalent: Typic Cryoboralf  
Profile Number: W. C. 236

Parent Material: Dark colored till  
Topography: d slope; W aspect  
Elevation above Lake Level: 10.2 metres  
Drainage: Moderately well to imperfect

Vegetation and Cover Estimates:

Tree Canopy: A. balsamea (30%), P. glauca (20%),  
B. papyrifera (20%).

Shrubs: L. borealis (5%), V. edule.

Herbs: V. renifolia, C. canadensis.





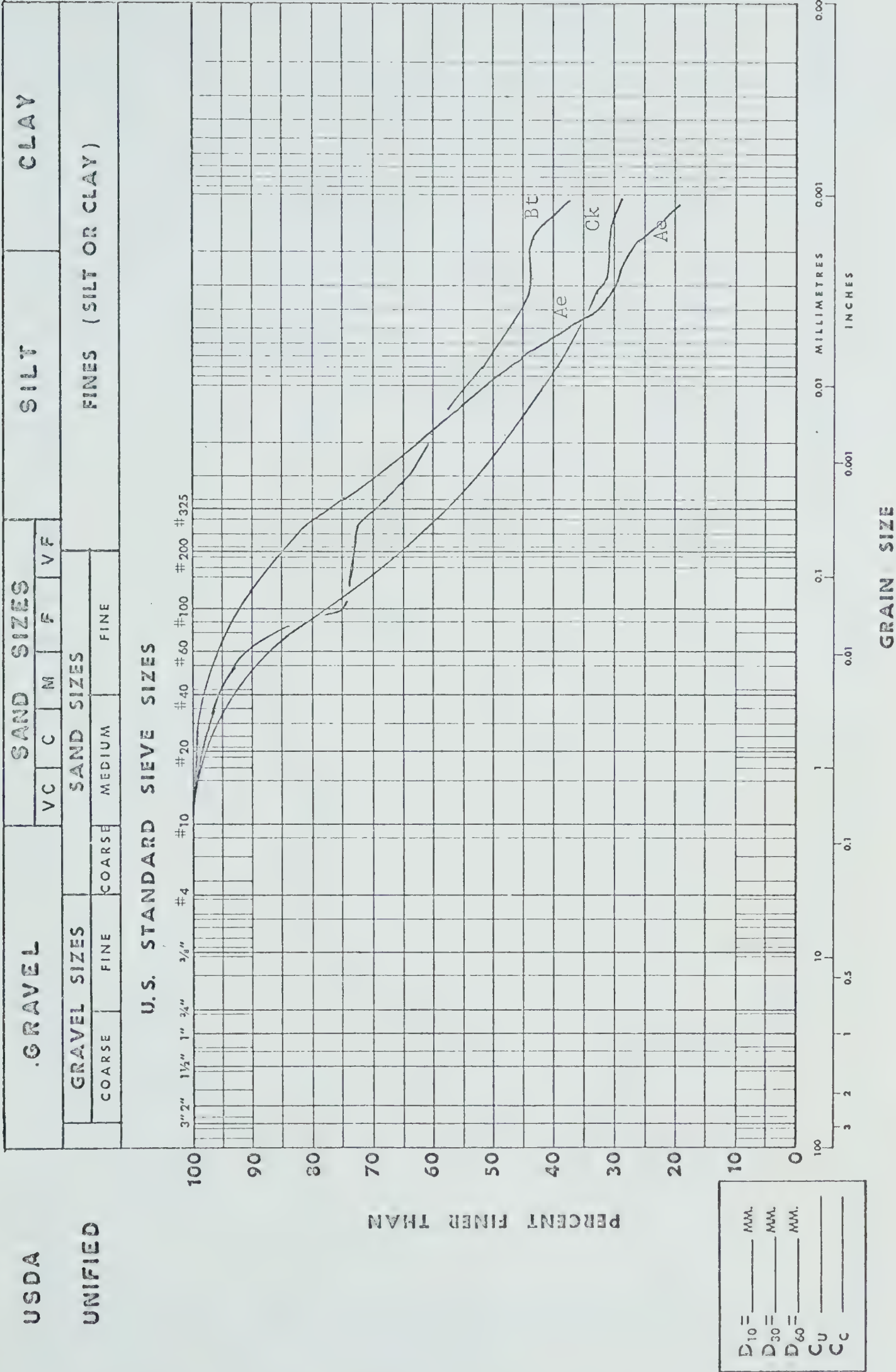
<u>HORIZON</u>	<u>DEPTH (cm.)</u>	<u>DESCRIPTION</u>
L-F	5-0	Partially decomposed leaf matter and conifer needles; some woody fragments.
Ah	0-3	Very dark brown (10YR 2/2) when moist; discontinuous; not described or sampled.
Ae	3-10	Dark brown to dark yellowish brown (10YR 4/3.5) when moist and pale brown to brown (10YR 5.5/3) when dry; SiL-SiCL; moderate medium platy; slightly plastic, friable, and hard; abundant fine random roots and abundant medium and coarse horizontal roots; common very fine vesicular pores and many very fine interstitial pores; pH 5.4; clear wavy boundary; 5 to 13 cm. thick.
BA	10-23	Brown to dark brown (10YR 4.5/3) when moist and pale brown (10YR 6/3) when dry; CL-C; moderate fine sub-angular blocky; plastic, firm, and hard to very hard; plentiful fine vertical roots and abundant medium and coarse random roots; common very fine vesicular pores and many very fine interstitial pores; pH 5.0; clear smooth boundary; 10 to 15 cm. thick.
Bt	23-43	Dark brown (10YR 3/3) exterior and dark yellowish brown (10YR 4/4) interior when moist and dark brown (10YR 4/3) exterior and pale brown (10YR 6/3) interior when dry; C; strong fine angular blocky; plastic, firm, and very hard; plentiful fine vertical roots and abundant medium vertical roots; few very fine vesicular pores and common very fine interstitial pores; many thin clay films on vertical ped surfaces and common thin clay films on horizontal ped surfaces; some stones and pebbles, mainly gravel size, very few cobbles; pH 4.7; gradual smooth boundary; 18 to 28 cm. thick.
BC	43-88	Dark brown (10YR 3/3) exterior and dark brown (10YR 4/3) interior when moist and dark yellowish brown (10YR 4/4) exterior and light yellowish brown (10YR 6/4) interior when dry; CL; weak medium prismatic macro-structure and moderate medium angular blocky meso-structure; plastic, firm, and very hard; few fine vertical expd roots and abundant medium vertical expd roots; common very fine interstitial pores and few very fine vesicular pores; few thin clay films on vertical surfaces of meso-structure and common thin clay films on vertical surfaces of macro-structure; stones and pebbles present, gravel size; pH 4.7; clear smooth boundary; 38 to 48 cm. thick.
Ck	88-155+	Very dark gray (10YR 3/1) and dark brown (10YR 4/3) when moist and gray to dark gray (10YR 4.5/1) and yellowish brown (10YR 5/4) when dry; CL; strong fine and medium angular blocky, breaks horizontally more readily than vertically; plastic, firm, and very hard; few fine expd vertical roots and plentiful medium expd vertical roots; common very fine interstitial pores; appears to be vertical clay flows along root channels, may be pressure surfaces; plentiful small stones, pebbles, and weathered iron stones; weak to moderately effervescent; few fine distinct carbonate accumulations; pH 7.0.



Profile Number W.C. 236

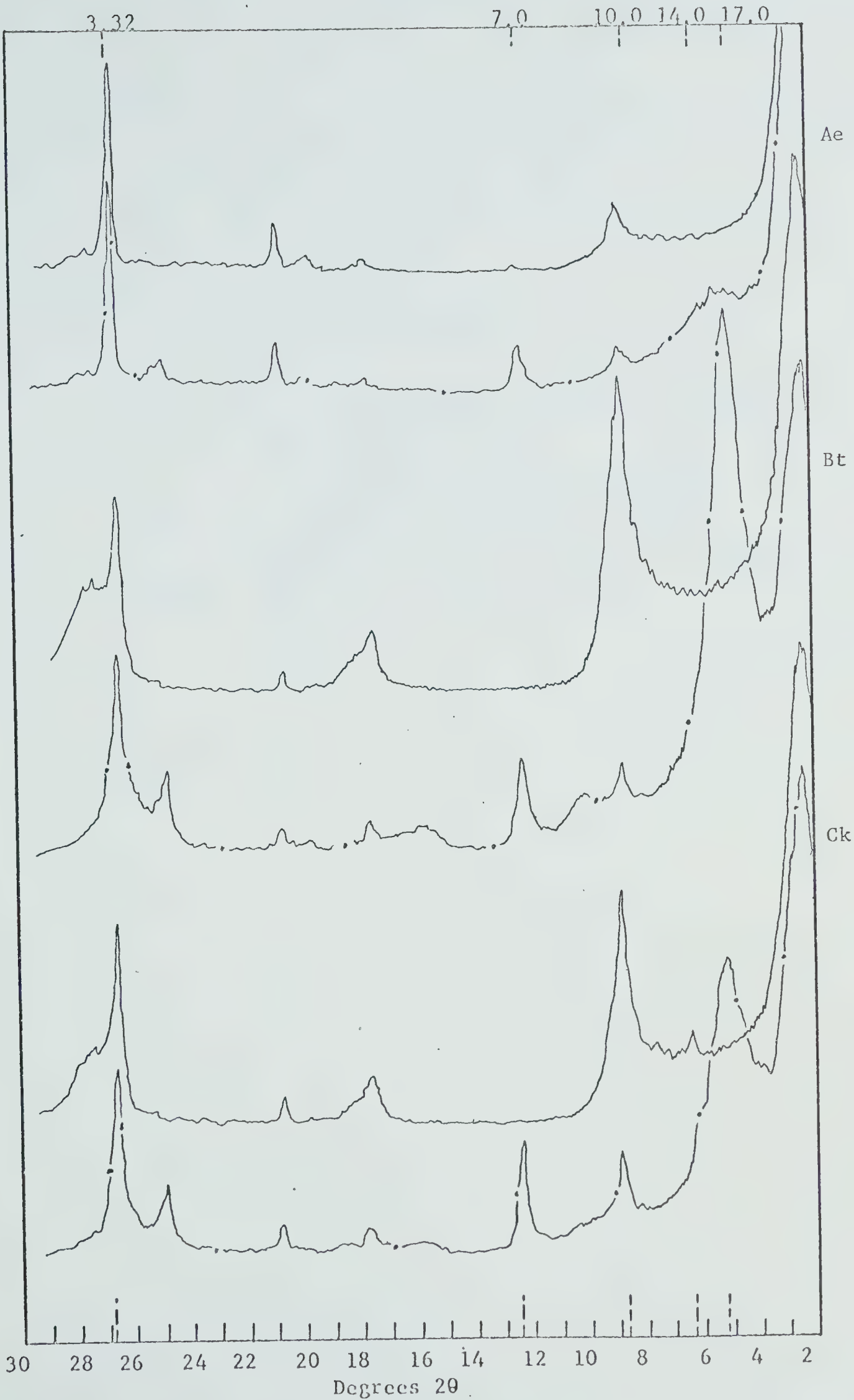
Horizon		Ae	BA	Bt	BC	Ck	Ck
Depth(cm)		3-10	10-23	23-43	43-88	88-125	125-155+
CHEMICAL ANALYSES							
pH		5.4	5.0	4.7	4.7	7.0	7.3
CaCO <sub>3</sub> Equiv.(%)		-	-	-	-	1.12	2.58
Org. C(%)		0.96	0.82	0.62	-	-	-
Exchange	H	3.91	3.75	3.94	3.09	0.19	-
Analysis	Ca	5.4	10.4	9.9	8.7	18.3	21.8
(meq/100 g)	Mg	6.4	6.2	9.3	7.1	6.7	7.0
	K	0.34	0.39	0.42	0.39	0.45	0.47
	Na	0.06	0.20	0.22	0.21	0.45	0.55
	TEC	14.5	20.4	22.5	18.8	16.7	15.2
Soluble	Ca	-	-	-	-	-	-
Salts	Mg	-	-	-	-	-	-
(meq/l)	Na	-	-	-	-	-	-
	SO <sub>4</sub>	-	-	-	-	-	-
EC(mmhos/cm)		-	-	-	-	-	-
PHYSICAL ANALYSES							
Particle	S	20	23	29	41	37	37
Size	Si	54	38	27	26	32	28
Analysis(%)	C	26	39	44	33	31	35
USDA Text. Class		SiL-SiCL	CL-C	C	CL	CL	CL
Unified Rating		CL	-	CL	-	-	CL
Atterberg	LL	27	-	39	-	-	32
Limits(%)	PI	8	-	21	-	-	20
	LI	0	-	0	-	-	0.35
Bulk	Db	1.16	-	1.60	-	-	-
Density(g/cc)	%M	20	-	19	-	-	-
Penetrometer	Ave	1.7	-	3.1	-	-	4.5
(kg/cm <sup>2</sup> )	Rge	1.0-2.5	-	2.3-3.8	-	-	-
% Nat. M		19	-	12	-	-	19
% Hygro. M		2.05	5.59	6.93	4.72	4.57	4.07
% 15 bar M		10	13	15	12	12	12
% 1/3 bar M		24	25	25	22	23	24
% Sat. Cap.		-	-	-	-	-	-







Angstroms





Classification

Sub-group: Orthic Gray Luvisol

Series: Grandin (Gn)

7th Approximation Equivalent: Typic Cryoboralf

Profile Number: W.C. 175

Parent Material: Dark colored till

Topography: b slope; S aspect

Elevation above Lake Level: 4.6 metres

Drainage: Moderately well to imperfect

Vegetation:

Tree canopy: P. tremuloides, P. glauca, A. balsamea,  
B. papyrifera

Shrubs and Half Shrubs: V. edule, C. stolonifera, dioica,  
R. glandulosum, Rosa, L. borealis

Herbs: C. canadensis, A. nudicaulis, canadense, V.  
cordifolia, M. nuda, R. pubescens, G. trifolium

Grasses: Very few

Mosses: Ptilium spp. and Hylocomium spp.



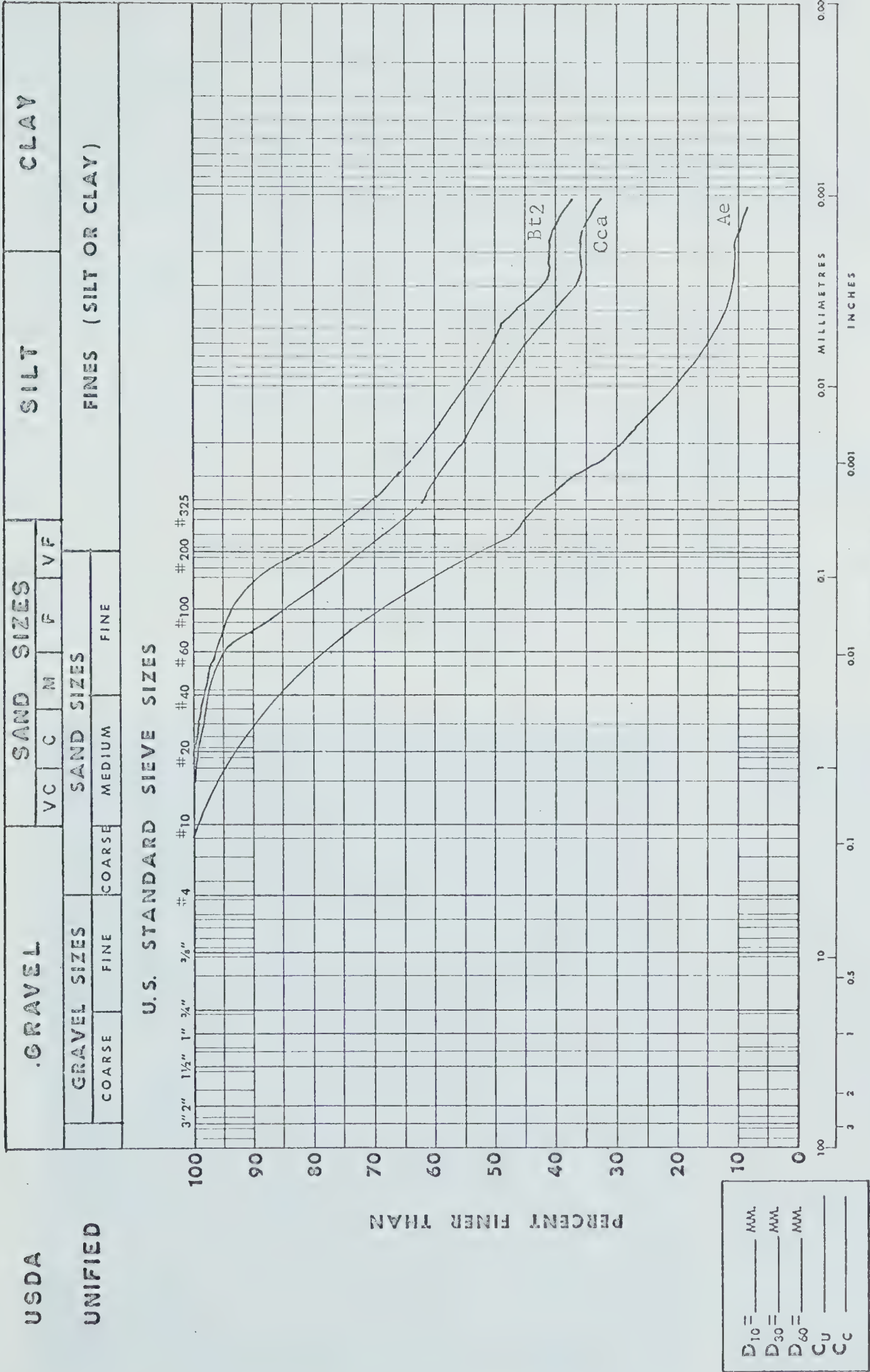
<u>HORIZON</u>	<u>DEPTH (cm.)</u>	<u>DESCRIPTION</u>
L-F	13-5	Dark brown (7.5YR 3/2) when moist and dark reddish brown (5YR 3/3) when dry; fibrous, partially decomposed leaf matter, woody fragments, and a few fungal mycelia; abundant, random, fine, medium, and coarse roots; clear wavy boundary; 5 to 10 cm. thick.
F	5-0	Dark reddish brown (5YR 2/2) and black (5YR 2/1) when moist and dark reddish brown (5YR 2/1.5) when dry; semi-decomposed leaf matter; abundant random fine, medium, and coarse roots; clear wavy boundary; 3 to 8 cm. thick.
Ae	0-10	Very dark grayish brown (10YR 3.5/2) when moist and light brownish gray (10YR 6/2) when dry; SL; weak fine platy; friable and soft; plentiful fine, medium, and coarse random roots; many very fine inped vesicular pores and many very fine continuous horizontal interstitial pores; pH 6.4; clear irregular boundary; 3 to 10 cm. thick.
Aegj	10-20	Grayish brown (10YR 5/2) matrix and yellowish brown (10YR 5/4) mottles when moist and white (10YR 8/2) when dry; SL; weak fine platy; friable and soft; plentiful fine and coarse roots; many very fine inped vesicular pores and many very fine horizontal interstitial pores; few fine faint mottles; coarse sand lens less than 3 cm. thick within; pH 6.2; clear wavy boundary; 8 to 15 cm. thick.
Bt <sub>1</sub>	20-35	Very dark grayish brown (10YR 3/2) ped exterior and dark brown to dark yellowish brown (10YR 3/3.5) ped interior when moist and grayish brown (10YR 5/2) ped exterior and dark brown (10YR 4/3) ped interior when dry; CL-C; weak medium prismatic macro-structure breaking to moderate fine sub-angular blocky; firm and very hard; plentiful fine, medium, and coarse vertical exped roots; many very fine interstitial pores; many very thin clay films on meso-structure ped surfaces and continuous clay films and vertical macro-structure ped surfaces; pH 6.9; clear smooth boundary; 10 to 15 cm. thick.
Bt <sub>2</sub>	35-60	Very dark grayish brown (10YR 3/2) ped exterior and dark brown (10YR 3/3) ped interior when moist and grayish brown (10YR 5/2) ped exterior and dark brown (10YR 3/3) ped interior when dry; C; moderate fine sub-angular blocky; firm and hard to very hard; few fine vertical exped roots and plentiful medium and coarse vertical exped roots; many very fine interstitial pores; common very thin clay films on vertical ped faces; pH 7.3; gradual smooth boundary; 20 to 30 cm. thick.
Bck	60-65	Very weakly effervescent; not described or sampled.
Ck	65+	Very dark grayish brown (10YR 3/2) and dark brown (10YR 3/3) when moist and dark grayish brown (10YR 4/2) and dark brown (10YR 4/3) when dry; CL; weak fine angular blocky; firm and hard; few fine vertical exped roots, and plentiful medium exped vertical roots; common very fine interstitial pores; moderately effervescent; pH 7.9.



Profile Number W.C. 175

Horizon		Ae	Aegj	Bt <sub>1</sub>	Bt <sub>2</sub>	Cca
Depth(cm)		0-10	10-20	20-35	35-60	65+
CHEMICAL ANALYSES						
pH		6.4	6.2	6.9	7.4	7.9
CaCO <sub>3</sub> Equiv.(%)		-	-	-	1.80	6.18
Org. C(%)		1.60	0.51	0.90	0.64	-
Exchange	H	2.76	1.62	0.62	-	-
Analysis	Ca	5.9	2.5	11.4	10.9	-
(meq/100 g)	Mg	3.7	2.8	10.2	9.7	-
	K	1.20	0.65	0.87	0.72	-
	Na	0.05	0.02	0.37	0.52	-
	TEC	12.3	5.9	22.0	19.8	-
Soluble	Ca	-	-	-	-	-
Salts	Mg	-	-	-	-	-
(meq/l)	Na	-	-	-	-	-
	SO <sub>4</sub>	-	-	-	-	-
EC(mmhos/cm)		-	-	-	-	-
PHYSICAL ANALYSES						
Particle	S	56	56	31	27	34
Size	Si	34	36	28	41	30
Analysis(%)	C	10	8	41	42	36
USDA Text. Class		SL	SL	CL-C	C	CL
Unified Rating		CL-ML	-	-	CL	CL
Atterberg	LL	18	-	-	38	38
Limits(%)	PI	-	-	-	21	22
	LI	-	-	-	0.10	-0.05
Bulk	Db	1.10	1.42	1.51	-	-
Density(g/cc)	%M	15	12	17	-	-
Penetrometer	Ave	-	-	-	-	-
(kg/cm <sup>2</sup> )	Rge	-	-	-	-	-
% Nat. M		-	-	-	19	15
% Hygro. M		1.92	1.13	4.07	3.71	2.75
% 15 bar M		6	3	14	13	13
% 1/3 bar M		14	11	22	21	25
% Sat. Cap.		-	-	-	-	-







Classification

Sub-group: Orthic Gray Luvisol  
Series: Maywood (Mw)  
7th Approximation Equivalent: Typic Cryoboralf  
Profile Number: W.C. 117

Parent Material: Lacustrine clay / Dark till  
Topography: c slope; SE aspect  
Elevation above Lake Level: 7.2 metres  
Drainage Class: Imperfect

Vegetation and Cover Estimates:

Tree Canopy: B. papyrifera (70%), P. glauca.

Shrubs: L. borealis (30%), Salix spp. (30%), Rosa spp. (10%), L. involucrata, C. stolonifera, canadensis, V. edule.

Herbs: C. canadensis, P. palmatus, G. borealis, F. virginiana, V. renifolia, P. asarifolia, M. nuda, A. rubra, E. angustifolia, Lathyrus spp., M. paniculata.

Grasses: Some.





<u>HORIZON</u>	<u>DEPTH (cm.)</u>	<u>DESCRIPTION</u>
L-F	5-3	Partially decomposed leaf matter and woody fragments.
H	3-0	Well decomposed leaf matter.
Ae <sub>1</sub>	0-10	Dark brown to dark grayish brown (10YR 4/2.5) when moist and pale brown to light brownish gray (10YR 6/2.5) when dry; SiL; moderate medium platy; very friable to friable and slightly hard; abundant fine vertical roots and abundant medium and coarse horizontal roots; many very fine vesicular and interstitial pores; pH 6.2; clear smooth boundary; 5 to 13 cm. thick.
Ae <sub>2</sub>	10-25	Dark brown (10YR 4/3) when moist and very pale brown (10YR 7/3) when dry; L; moderate medium platy; friable and hard; abundant fine vertical roots and plentiful medium and coarse horizontal roots; many very fine vesicular and interstitial pores; pH 5.6; abrupt smooth boundary; 13 to 23 cm. thick.
AB	25-28	Not sampled or described.
Bt <sub>1</sub>	28-48	Dark grayish brown (2.5Y 4/2) when moist and dark yellowish brown to dark brown (10YR 4.5/3) when dry; C; weak medium prismatic macro-structure and strong fine angular blocky meso-structure; very plastic, firm, and very hard; abundant fine vertical expd roots and plentiful medium random expd roots; many very fine interstitial pores; many thin clay films on vertical ped surfaces and common thin clay films on horizontal ped surfaces; pH 4.8; clear smooth boundary; 18 to 25 cm. thick.
Bt <sub>2</sub>	48-75	Very dark grayish brown (10YR 3/2) exterior and yellowish brown (10YR 5/4) interior when moist and dark grayish brown (10YR 4/2) exterior and pale brown to light yellowish brown (10YR 6.5/4) interior when dry; SiC-C; strong fine angular blocky; plastic, firm, and very hard; many fine random expd roots and few medium expd roots; many very fine interstitial pores; common thin clay films on vertical ped surfaces and few clay films on horizontal ped surfaces; pH 4.9; clear smooth boundary; 23 to 30 cm. thick.
BC	75-100	Very dark gray (10YR 3/1) exterior and brown (10YR 4.5/3) interior when moist and very dark grayish brown (10YR 3/2) exterior and brown (10YR 5/3) interior when dry; C; moderate fine angular blocky; plastic, firm, and slightly hard to hard; few fine and medium vertical expd roots; many very fine interstitial pores; few to common thin clay films on vertical ped surfaces and few thin clay films on horizontal ped surfaces; pH 5.7; abrupt smooth boundary; 20 to 30 cm. thick.
II Ck	100-150+	Very dark brown (10YR 2/2) when moist and grayish brown (2.5Y 5/2) and yellowish brown (10YR 5/4) when dry; CL-C; weak fine angular blocky; slightly plastic, friable, and very hard; few fine and medium vertical expd roots; few very fine vesicular pores and common very fine interstitial pores; weak to moderately effervescent, few, fine distinct carbonate accumulations; many weathered iron stones and other pebbles of less than cobble size; pH 7.1.



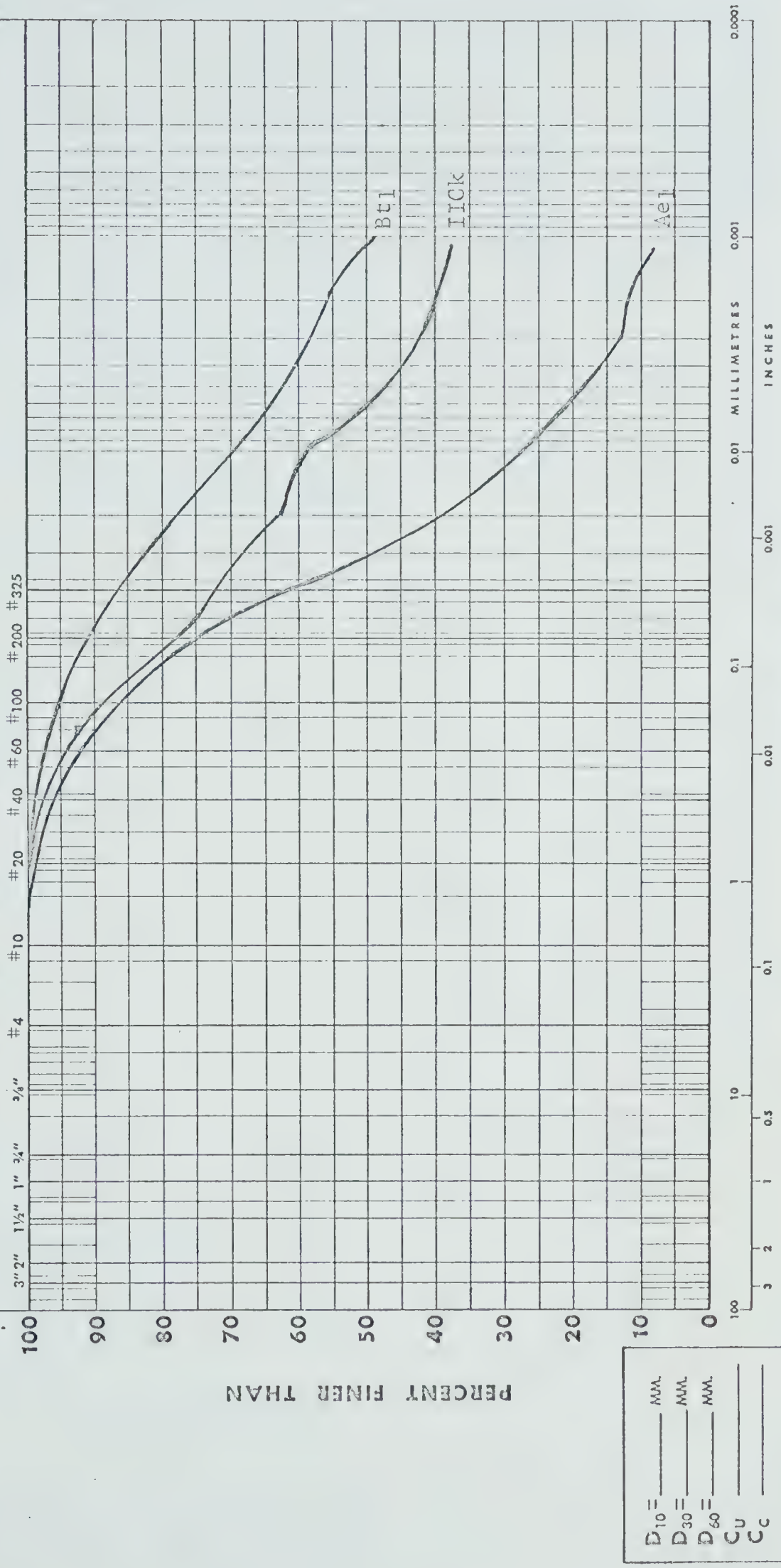
Profile Number W.C. 117

Horizon		Ae <sub>1</sub>	Ae <sub>2</sub>	Bt <sub>1</sub>	Bt <sub>2</sub>	BC	IICk
Depth(cm)		0-10	10-25	28-48	48-75	75-100	100-150+
CHEMICAL ANALYSES							
pH		6.2	5.6	4.8	4.9	5.7	7.1
CaCO <sub>3</sub> Equiv.(%)		-	-	-	-	-	3.71
Org. C(%)		0.42	0.33	0.49	0.65	-	-
Exchange	H	2.01	2.01	3.24	3.09	1.28	-
Analysis	Ca	5.4	5.0	17.4	16.3	15.8	19.6
(meq/100 g)	Mg	1.6	1.7	11.8	9.1	11.6	7.5
	K	0.52	0.38	0.62	0.58	0.59	0.43
	Na	0.03	0.04	0.19	0.20	0.32	0.18
	TEC	8.1	8.0	28.5	28.5	27.8	16.7
Soluble	Ca	-	-	-	-	-	-
Salts	Mg	-	-	-	-	-	-
(meq/1)	Na	-	-	-	-	-	-
	SO <sub>4</sub>	-	-	-	-	-	-
EC(mmhos/cm)		-	-	-	-	-	-
PHYSICAL ANALYSES							
Particle	S	34	39	12	2	10	26
Size	Si	54	45	32	40	37	34
Analysis(%)	C	12	16	56	58	53	40
USDA Text. Class		SiL	L	C	SiC-C	C	CL-C
Unified Rating		CL-ML	-	CL-CH	-	-	CL
Atterberg	LL	20	-	51	-	-	35
Limits(%)	PI	-	-	27	-	-	17
	LI	-	-	0.07	-	-	-0.18
Bulk	Db	1.47	-	-	-	-	-
Density(g/cc)	%M	21	-	-	-	-	-
Penetrometer	Ave	1.36	-	1.37	-	-	3.97
(kg/cm <sup>2</sup> )	Rge	0.8-1.8	-	1.0-1.8	-	-	3.3-4.3
% Nat. M		19	-	26	-	-	15
% Hygro. M		2.11	1.37	7.45	12.33	3.23	3.97
% 15 bar M		5	6	20	20	20	12
% 1/3 bar M		18	17	32	33	36	23
% Sat. Cap.		-	-	-	-	-	-



USDA  UNIFIED	GRAVEL		SAND SIZES						SILT	CLAY
			VC	C	M	F	VF			
	GRAVEL SIZES		SAND SIZES				FINES (SILT OR CLAY)			
COARSE	FINE	COARSE	MEDIUM	FINE						

U.S. STANDARD SIEVE SIZES





Angstroms

3.32

7.0

10.0

14.0

17.0

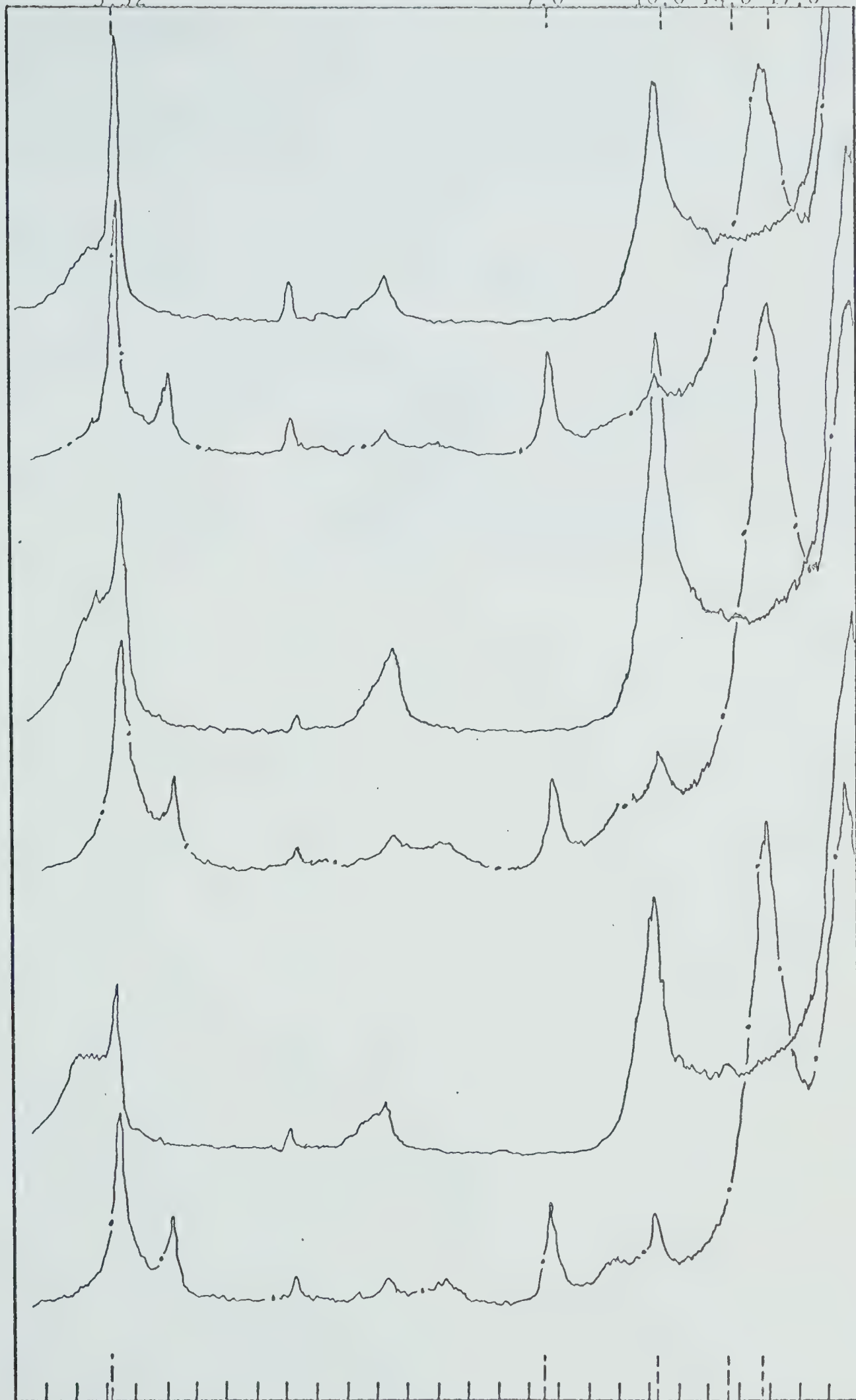
Ae1

Bt1

IICk

30 28 26 24 22 20 18 16 14 12 10 8 6 4 2

Degrees 2θ





Classification

Sub-group: Orthic Gray Luvisol  
 Series: Maywood (Mw)  
 7th Approximation Equivalent: Typic Cryoboralf  
 Profile Number: W.C. 212

Parent Material: Lacustrine clay  
 Topography: d slope; NW aspect  
 Elevation above Lake Level: 14.4 metres  
 Drainage Class: Imperfect

Vegetation and Cover Estimates:

Tree Canopy: B. papyrifera (50%), A. balsamea (30%).  
 Shrubs: R. strigosus, R. pubescens, L. borealis,  
R. hirtellum.  
 Herbs: G. trifolium, A. nudicaulis, D. trachycarpum.  
 Mosses: Ptilium and Hylocomium spp.



<u>HORIZON</u>	<u>DEPTH (cm.)</u>	<u>DESCRIPTION</u>
L-H	5-0	Semi- and well decomposed leaf matter and woody fragments.
Ahe	0-5	Very dark brown (10YR 2/2) when moist and dark grayish brown (10YR 3.5/2) when dry; SiCL; weak fine platy; slightly sticky, friable, and slightly hard; abundant fine vertical roots and abundant medium and coarse horizontal roots; many very fine vesicular pores; pH 5.9; clear wavy boundary; 3 to 13 cm. thick.
Ae	5-8	Dark brown (10YR 3/3) when moist; not described or sampled.
Bt <sub>1</sub>	8-33	Dark grayish brown (10YR 3.5/2) exterior and interior when moist and dark grayish brown (10YR 4/2) exterior and interior when dry; HC; moderate to strong fine sub-angular blocky; sticky, firm, and very hard; plentiful fine vertical roots and abundant medium and coarse random roots; many very fine interstitial pores; many thin clay films on vertical ped surfaces; pH 4.5; clear smooth boundary; 20 to 30 cm. thick.
Bt <sub>2</sub>	33-58	Dark grayish brown (10YR 4/2) exterior and dark brown (10YR 4/3) interior when moist and gray (10YR 5/1) exterior and brown (10YR 5/3) interior when dry; HC; strong fine angular blocky; sticky to very sticky, plastic, firm, and hard to very hard; few fine vertical roots and abundant medium random roots; common very fine interstitial pores; many thin clay films on vertical ped surfaces and common thin clay films on horizontal ped surfaces; pH 4.4; clear smooth boundary; 20 to 33 cm. thick.
Bck	58-105	Very dark grayish brown (10YR 3/2) exterior and dark brown (10YR 3/3) interior when moist and grayish brown (10YR 5/2) exterior and pale brown (10YR 6/3) interior when dry; SiC-C; weak medium prismatic macro-structure and moderately strong fine angular blocky meso-structure; sticky, plastic, firm, and hard to very hard; few fine vertical roots and abundant medium vertical roots; common very fine interstitial pores; clay flows evident on vertical cleavage surfaces of macro-structure and common clay films on vertical surfaces of meso-structure; weakly effervescent; pH 6.3; clear smooth boundary; 35 to 55 cm. thick.
Cca	105-125	Very dark brown (10YR 2/2) with thin bands of dark brown (10YR 4/3) when moist and dark gray (10YR 4/1) with thin bands of light yellowish brown (10YR 6/4) when dry; SiC; very weak fine angular blocky to massive; plastic, firm, and hard; few fine vertical roots and plentiful medium vertical roots; common very fine vesicular pores; moderately effervescent with common fine and medium white (10YR 8/1) prominent carbonate accumulations; pH 7.2; clear smooth boundary; 18 to 23 cm. thick.
Ck	125-145	Very dark grayish brown (10YR 3/2) and dark brown (10YR 4/3) when moist and gray to dark gray (10YR 4.5/1) and light yellowish brown (10YR 6/4) when dry; SiC-C; very weak fine angular blocky to massive; plastic, firm, and very hard; few fine and medium vertical roots; few very fine interstitial pores; moderate to weakly effervescent; pH 7.2; clear smooth boundary; 15 to 20 cm. thick.
II Ck	145-175+	Gray to dark gray (10YR 4.5/1) when dry; SiC-C; weak fine angular blocky to massive; firm and very hard; shaly till with many weathered iron stones and few other pebbles; moderately effervescent; pH 7.4.



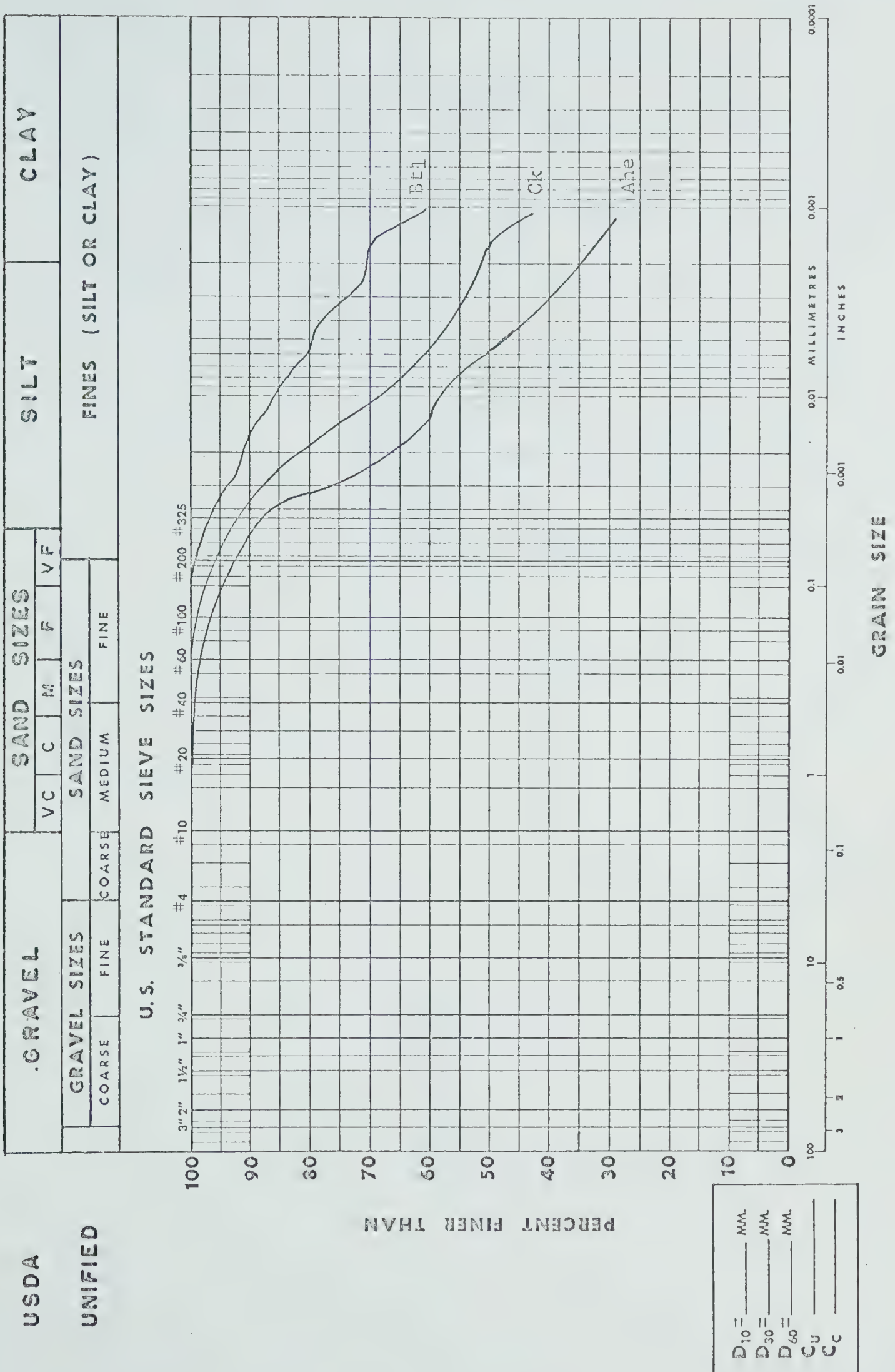
Profile Number W.C. 212

Horizon		Ahe	Bt <sub>1</sub>	Bt <sub>2</sub>	BCK	Cca	Ck	IICk
Depth(cm)		0-5	8-33	33-58	58-105	105-125	125-145	145-175+
CHEMICAL ANALYSES								
pH		5.9	4.5	4.4	7.2	7.2	7.2	7.4
CaCO <sub>3</sub> Equiv.(%)		-	-	-	-	1.74	0.87	1.08
Org. C(%)		5.66	1.41	1.59	-	-	-	-
Exchange	H	6.11	5.49	4.76	0.39	-	-	-
Analysis	Ca	19.8	15.8	13.9	15.6	18.8	15.3	15.8
(meq/100 g)	Mg	7.6	12.3	11.5	12.5	11.0	10.1	10.9
	K	1.30	0.75	0.73	0.72	0.60	0.59	0.59
	Na	0.06	0.37	0.15	0.16	0.13	0.13	0.42
	TEC	35.3	36.0	30.6	26.8	20.8	21.6	20.5
Soluble	Ca	-	-	-	-	-	-	-
Salts	Mg	-	-	-	-	-	-	-
(meq/l)	Na	-	-	-	-	-	-	-
	SO <sub>4</sub>	-	-	-	-	-	-	-
EC(mmhos/cm)		-	-	-	-	-	-	-
PHYSICAL ANALYSES								
Particle	S	13	2	4	7	8	7	8
Size	Si	51	28	34	42	45	41	42
Analysis(%)	C	36	70	62	51	47	52	50
USDA Text. Class		SiCL	HC	HC	SiC-C	SiC	SiC-C	SiC-C
Unified Rating		ML	MH	-	-	-	CL	-
Atterberg	LL	46	56	-	-	-	43	-
Limits(%)	PI	9	22	-	-	-	20	-
	LI	0	-0.27	-	-	-	-0.45	-
Bulk	Db	0.96	-	1.35	-	-	-	-
Density(g/cc)	%M	37	-	24	-	-	-	-
Penetrometer	Ave	-	1.57	-	-	-	4.5	-
(kg/cm <sup>2</sup> )	Rge	-	1.1-1.9	-	-	-	-	-
% Nat. M		-	28	-	-	-	14	-
% Hygro. M		11.76	7.51	9.67	5.88	8.79	4.16	5.71
% 15 bar M		20	23	21	19	16	16	17
% 1/3 bar M		37	40	37	38	33	30	32
% Sat. Cap.		-	-	-	-	-	-	-



ASDA

QWERTZ





Classification

Sub-group: Orthic Dark Gray Luvisol  
 Series: Macola (M1)  
 7th Approximation Equivalent: Mollic Cryoboralf  
 Profile Number: W.C. 46

Parent Material: Lacustrine clay  
 Topography: c slopes, E aspect  
 Elevation above Lake Level: 18.2 metres  
 Drainage Class: Imperfect

Vegetation and Cover Estimates:

Tree Canopy: B. papyrifera (60%), P. tremuloides (40%),  
P. glauca (trace).  
 Shrubs: A. alnifolia (15%), P. americana (5%),  
R. strigosus (50%), R. glandulosum (10%),  
Rosa spp. (10%).  
 Herbs: A. nudicaulis (40%), G. triflorum, P.  
asarifolia, C. canadensis, R. pubescens,  
V. renifolia.  
 Grasses: Trace.  
 Mosses: Ptilium and Hylocomium spp.



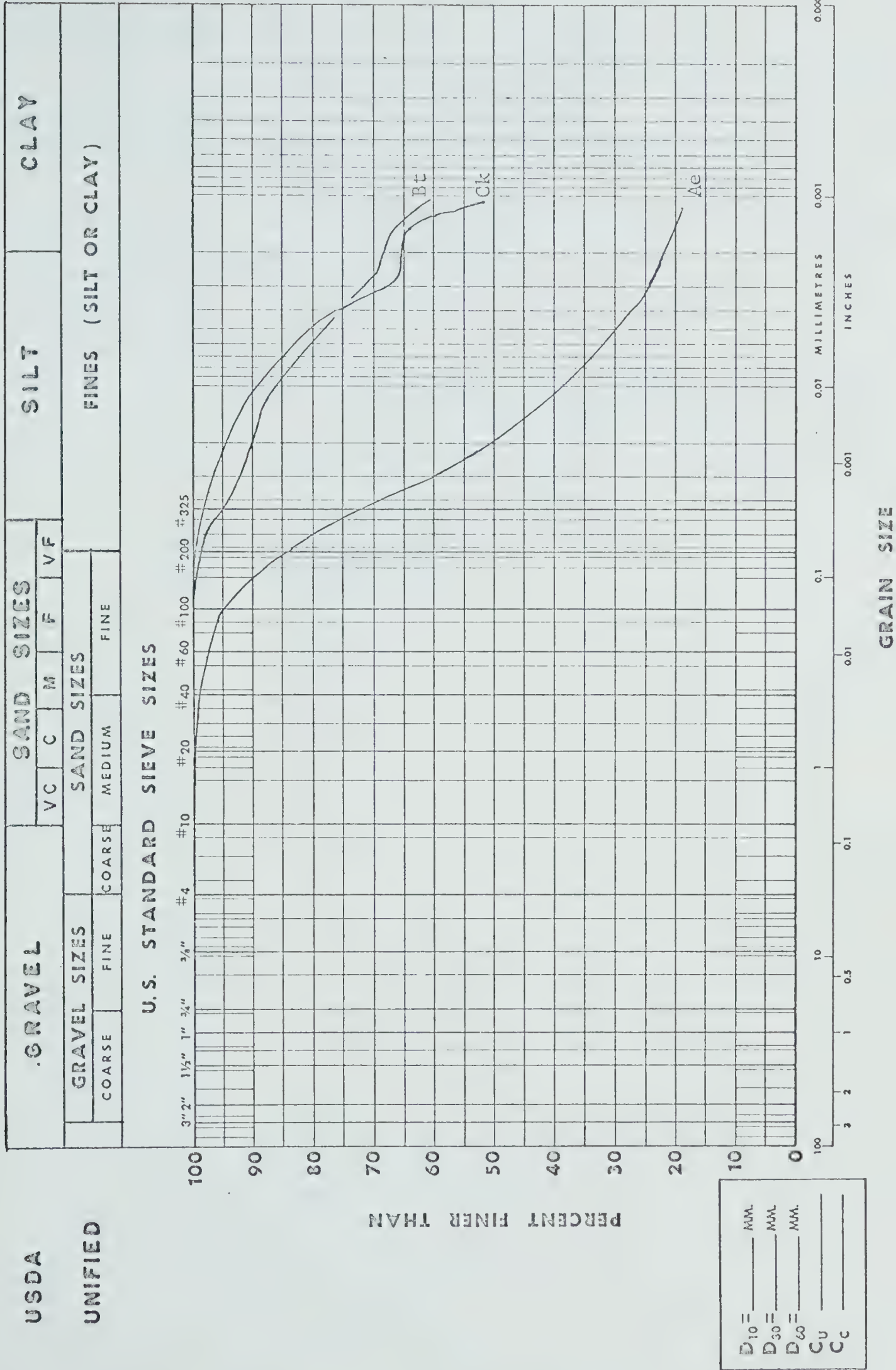
<u>HORIZON</u>	<u>DEPTH (cm.)</u>	<u>DESCRIPTION</u>
L-F	15-5	Partially decomposed leaf matter and woody fragments.
F	5-0	Very dark brown (10YR 2/2) when moist and dark reddish brown (5YR 2/2) when dry; semi-decomposed leaf matter and woody fragments.
Ahe	0-8	Very dark grayish brown (10YR 3/2) when moist and dark gray (10YR 4/1) when dry; SiL; weak medium platy; very friable and soft; abundant fine, medium, and coarse horizontal and oblique roots; many random inped vesicular pores; pH 6.1; clear, wavy boundary; 5 to 10 cm. thick.
Ae	8-15	Dark grayish brown (10YR 4/2) and light brownish gray (10YR 6/2) when moist and light gray to light brownish gray (10YR 6/2) when dry; SiL-L; moderate fine platy; friable and soft to slightly hard; plentiful fine, vertical, inped roots and abundant medium and coarse vertical inped roots; many very fine inped vesicular pores and many very fine exped interstitial pores; pH 5.9; clear smooth boundary; 3 to 10 cm. thick.
AB	15-18	Not sampled or described.
Bt	18-50	Very dark grayish brown (10YR 3/2) ped exterior and interior when moist and dark grayish brown to grayish brown (10YR 4.5/2) ped exterior and interior when dry; HC; weak medium prismatic macro-structure and moderate fine sub-angular blocky meso-structure; firm and very hard; plentiful fine, medium, and coarse oblique, exped roots; many very fine interstitial pores; many thin clay films on vertical ped surfaces and common thin clay films on horizontal ped surfaces; pH 4.6; clear smooth boundary; 20 to 40 cm. thick.
BC	50-58	Dark brown (10YR 3.5/3) ped exterior and dark brown (10YR 4/3) ped interior when moist and pale brown (10YR 6/3) ped exterior and light gray (10YR 7/2) ped interior when dry; SiCL; weak to moderate medium sub angular blocky; friable and hard; plentiful fine, medium and coarse vertical, exped roots; common very fine inped vesicular pores and common very fine, exped, interstitial pores; appears platy in some places suggesting stratification; pH 4.9; clear smooth boundary; 5 to 20 cm. thick.
Bck	58-103	Very dark gray (2.5Y 3/1) when moist and gray (10YR 5/1) to dark grayish brown (2.5Y 4/2) when dry; HC; weak medium prismatic macro structure and moderate fine angular blocky meso structure; firm and hard to very hard; few fine vertical roots and plentiful medium and coarse vertical roots; many very fine interstitial pores; few thin clay films on vertical ped surfaces of macro structure; weakly effervescent; pH 6.6; clear wavy boundary; 33 to 50 cm. thick.
Cca	103-133	Alternating layers of dark grayish brown (10YR 4/2) and very dark gray (10YR 3/1) less than 3 cm. thick when moist and light brownish gray (2.5Y 6/2) and gray (10YR 5/1) when dry; SiC; weak fine angular blocky; firm and hard; few fine horizontal exped roots, few medium and coarse vertical exped roots; abundant very fine interstitial pores; moderate to strongly effervescent; pH 7.1; abrupt wavy boundary; 25 to 38 cm. thick.
Ck	133-150+	Very dark gray (10YR 3/1) when moist and gray (10YR 5/1) when dry; HC; weak fine angular blocky to amorphous; firm and hard; few fine, medium, and coarse vertical exped roots; few very fine vesicular pores and plentiful very fine interstitial pores; moderately effervescent and few medium prominent carbonate accumulations; pH 7.2.



Profile Number W.C. 46

Horizon		Ahe	Ae	Bt	BC	BCK	Cca	Ck
Depth(cm)		0-8	8-15	18-50	50-58	58-103	103-133	133-150+
CHEMICAL ANALYSES								
pH		6.1	5.9	4.6	4.9	7.1	7.1	7.2
CaCO <sub>3</sub> Equiv.(%)		-	-	-	-	-	1.37	1.08
Org. C(%)		1.72	0.57	1.47	-	-	-	-
Exchange	H	2.89	4.14	4.76	2.67	0.27	-	-
Analysis	Ca	6.9	6.7	17.3	11.9	25.0	22.3	26.2
(meq/100 g)	Mg	3.4	2.4	11.5	7.3	10.5	8.9	6.8
	K	1.04	0.52	0.75	0.59	0.79	0.79	0.85
	Na	0.01	0.05	0.14	0.10	0.15	0.13	0.15
	TEC	14.7	11.9	34.5	21.7	32.0	26.3	26.8
Soluble	Ca	-	-	-	-	-	-	-
Salts	Mg	-	-	-	-	-	-	-
(meq/l)	Na	-	-	-	-	-	-	-
	SO <sub>4</sub>	-	-	-	-	-	-	-
EC(mmhos/cm)		-	-	-	-	-	-	-
PHYSICAL ANALYSES								
Particle	S	25	26	3	13	3	2	1
Size	Si	60	52	29	51	29	42	34
Analysis(%)	C	15	22	68	36	68	56	65
USDA Text. Class		SiL	SiL-L	HC	SiCL	HC	SiC	HC
Unified Rating		-	CL-ML	CH	-	-	-	CH
Atterberg	LL	-	24	61	-	-	-	67
Limits(%)	PI	-	6	32	-	-	-	37
	LI	-	0.5	-0.7	-	-	-	-0.08
Bulk	Db	1.17	-	1.32	-	1.35	-	-
Density(g/cc)	%M	17	-	26	-	28	-	-
Penetrometer	Ave	-	1.38	2.34	-	-	-	3.56
(kg/cm <sup>2</sup> )	Rge	-	1.0-2.1	1.95-2.75	-	-	-	2.5-4.3
% Nat. M		-	21	6	-	-	-	27
% Hygro. M		2.33	1.71	7.63	3.47	9.72	6.55	11.89
% 15 bar M		8	8	23	15	25	21	25
% 1/3 bar M		20	20	63	30	39	40	44
% Sat. Cap.		-	-	-	-	-	-	-







Classification

Sub-group: Peaty Low Humic Eluviated Gleysol  
 Series: Snipe (Sn)  
 7th Approximation Equivalent: Histic Cryalbaqualf  
 Profile Number: W.C. 45

Parent Material: Lacustrine clay  
 Topography: a slope; in depression  
 Elevation above Lake Level: 6.5 metres  
 Drainage Class: Poor to very poor

Vegetation and Cover Estimates:

Tree Canopy: B. papyrifera (10%), P. glauca (on depression border), P. tremuloides (on depression border).  
 Shrubs: Salix spp. (70% on depression border), Alnus spp. (on depression border).  
 Herbs: Epilobium angustifolia (5%).  
 Grasses: 90% in depression.  
 Other: Equisetum spp.



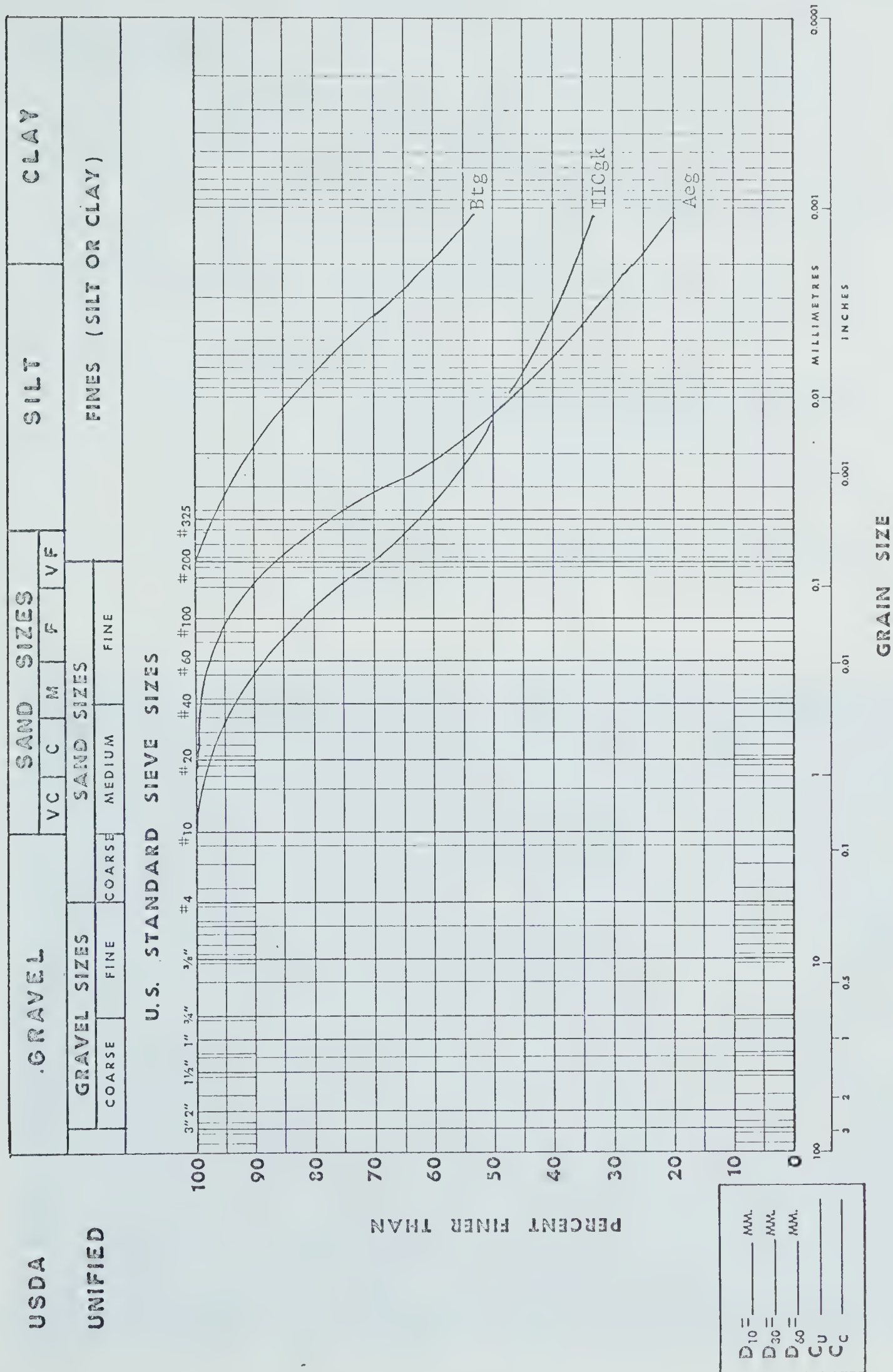
<u>HORIZON</u>	<u>DEPTH (cm.)</u>	<u>DESCRIPTION</u>
Of	28-20	Dark yellowish brown (10YR 4/6) when moist and yellowish brown (10YR 5/6) when dry; undecomposed grass matter; individual components readily identified; abrupt smooth boundary; 5 to 10 cm. thick.
Om <sub>1</sub>	20-13	Very dark brown (7.5YR 2/3) when moist and dark brown (7.5YR 3/4) when dry; partially decomposed grass matter; individual components still identifiable; abrupt smooth boundary; 5 to 10 cm. thick.
Om <sub>2</sub>	13-5	Very dark brown (7.5YR 2/2) when moist and dark brown (7.5YR 3/3) when dry; semi-decomposed grass matter; individual components difficult to identify; clear smooth boundary; 5 to 10 cm. thick.
Oh	5-0	Black (7.5YR 2/1) when moist and black (10YR 2/1) when dry; well decomposed grass matter; clear smooth boundary; 3 to 8 cm. thick.
Ahe	0-8	Very dark brown (10YR 2/3) when moist and gray (10YR 5/1) when dry; SiL; moderate medium platy; firm and slightly hard; abundant fine random roots; many very fine interstitial pores and common very fine vesicular pores; pH 5.7; abrupt wavy boundary; 3 to 13 cm. thick.
Aeg	8-18	Dark grayish brown (10YR 4/2) matrix color and dark reddish brown (5YR 3/4) mottle color when moist and light gray (10YR 7/2) matrix color and reddish yellow (7.5YR 6/6) mottle color when dry; SiL; strong medium platy; firm and hard; many fine vertical roots; many very fine interstitial pores and many fine continuous vertical tubular pores (root channels) along which mottles are concentrated; few fine prominent mottles; pH 5.6; clear wavy boundary; 5 to 13 cm. thick.
Btg	18-28	Gray to dark gray (10YR 4.5/1) matrix and dark reddish brown (5YR 3/5) mottles when moist and gray (10YR 5.5/1) matrix and dark yellowish brown (10YR 4/6) mottles when dry; C-HC; moderate very fine angular blocky, almost shot-like; plastic, friable and very hard; abundant fine vertical roots, and few coarse horizontal roots; many very fine continuous vertical tubular pores in which mottling is concentrated; common to many thin clay films on vertical ped surfaces and common thin clay films on horizontal ped surfaces; many fine prominent mottles; pH 5.3; clear smooth boundary; 10 to 18 cm. thick.
BCgk <sub>1</sub>	28-53	Dark gray (10YR 4/1) matrix and dark yellowish brown (5YR 4/7) mottles when moist and gray (10YR 5/1) matrix and strong brown (7.5YR 4/6) when dry; C; weak to moderate fine angular blocky; plastic, firm and very hard; plentiful fine vertical roots; many very fine interstitial pores; few to common clay films on vertical ped surfaces; very many fine prominent mottles; weakly effervescent; pH 5.2; gradual smooth boundary; 20 to 30 cm. thick.
BCgk <sub>2</sub>	53-80	Dark gray (10YR 4/1) matrix and yellowish red (5YR 4/7) mottles when moist and gray (10YR 5.5/1) matrix and yellowish red (5YR 4.5/8) mottles when dry; C; weak fine angular blocky; plastic, firm and very hard; plentiful fine vertical roots; many very fine interstitial pores; few to common clay films on vertical ped surfaces; many fine distinct mottles; weakly effervescent; pH 5.3; clear smooth boundary; 23 to 33 cm. thick.
II Cgk	80-100	Dark gray (10YR 3.5/1) matrix and yellowish red (5YR 3/6) mottles when moist and gray (10YR 4.5/1) matrix and strong brown (7.5YR 5/6) mottles when dry; CL; weak fine angular blocky to massive; plastic, firm, and very hard; plentiful fine vertical roots; many very fine vesicular and interstitial pores and common vertical tubular pores; common fine and medium prominent mottles not confined to tubular pores (root channels); weakly effervescent; dark shaly till; pH 5.4; clear smooth boundary; 18 cm. thick.
III C	100-115+	Gravelly outwash; water seeping in at 117 cm.



Profile Number W.C. 45

Horizon		Ahe	Aeg	Btg	BCgk <sub>1</sub>	BCgk <sub>2</sub>	IICgk
Depth(cm)		0-8	8-18	18-28	28-53	53-80	80-100
CHEMICAL ANALYSES							
pH		5.7	5.6	5.3	5.4	5.4	5.5
CaCO <sub>3</sub> Equiv.(%)		-	-	-	-	-	-
Org. C(%)		2.28	0.81	1.33	-	-	-
Exchange	H	4.25	3.02	4.37	3.05	2.48	1.97
Analysis	Ca	7.4	6.9	15.3	14.9	13.9	9.9
(meq/100 g)	Mg	4.8	4.1	11.1	11.0	10.6	5.9
	K	0.31	0.27	0.55	0.59	0.68	0.52
	Na	0.12	0.11	0.23	0.22	0.31	0.18
	TEC	16.4	13.8	32.3	29.5	28.3	17.9
Soluble	Ca	-	-	-	-	-	-
Salts	Mg	-	-	-	-	-	-
(meq/l)	Na	-	-	-	-	-	-
	SO <sub>4</sub>	-	-	-	-	-	-
EC(mmhos/cm)		-	-	-	-	-	-
PHYSICAL ANALYSES							
Particle	S	20	20	3	4	5	36
Size	Si	58	53	37	39	39	27
Analysis(%)	C	22	27	60	57	56	37
USDA Text. Class		SiL	SiL	C-HC	C	C	CL
Unified Rating		-	CL-ML	MH-CH	-	-	CL
Atterberg	LL	-	23	53	-	-	32
Limits(%)	PI	-	5	23	-	-	14
	LI	-	1.4	-	-	-	-
Bulk	Db	-	1.37	-	-	-	-
Density(g/cc)	%M	-	25	-	-	-	-
Penetrometer	Ave	-	-	-	-	-	-
(kg/cm <sup>2</sup> )	Rge	-	-	-	-	-	-
% Nat. M		-	-	-	-	-	-
% Hygro. M		2.74	3.65	10.36	8.52	7.28	3.72
% 15 bar M		10	9	22	23	23	12
% 1/3 bar M		27	25	38	37	37	22
% 1/10 bar M		-	-	-	-	-	-
% Sat. Cap.		-	-	-	-	-	-







Classification

Sub-group: Orthic Gray Luvisol  
 Series: Culp (Cu)  
 7th Approximation Equivalent: Topic Cryoboralf  
 Profile Number: W.C. 210

Parent Material: Alluvial sand  
 Topography: d slope; SE aspect  
 Elevation above Lake Level: 18 metres  
 Drainage: Well to rapid

Vegetation and Cover Estimates:

Tree Canopy: B. papyrifera (80%), P. pennsylvanica and  
P. americana (25%), P. glanca (T), P.  
tremuloidies (T).

Shrubs and Half Shrubs: C. stolonifera, R. glandulosum,  
Rosa spp.

Herbs: G. trifolium, R. pubescens, A. nudicaulis.

Grasses: Moderate grass cover.





<u>HORIZON</u>	<u>DEPTH (cm.)</u>	<u>DESCRIPTION</u>
L	5-3	Grass and leaf matter easily recognized; woody fragments.
L-F	3-0	Dark reddish brown (5YR 2.5/2) when moist; partially decomposed grass and leaf matter.
Ahe	0-5	Very dark brown (10YR 2/2) when moist and very dark grayish brown (10YR 4/2) when dry; LS; single grained; loose; abundant fine random roots and plentiful medium and coarse horizontal roots; abundant fine vesicular pores; pH 5.2; abrupt wavy boundary; 5 to 10 cm. thick.
Ae	5-15	Dark grayish brown to dark brown (10YR 3.5/2.5) when moist and grayish brown (10YR 5/2) when dry; LS; weak medium platy; loose and soft; abundant fine vertical roots and plentiful medium and coarse horizontal roots; many fine vesicular pores; pH 4.8; abrupt smooth boundary; 8 to 13 cm. thick.
Bt <sub>1</sub>	15-25	Dark yellowish brown (10YR 3/4) when moist and dark brown (10YR 4/3) when dry; SL; weak medium sub-angular blocky; very friable and soft; plentiful fine vertical roots and plentiful medium and coarse horizontal roots; common very fine inped vesicular pores; clay bridging between sand grains visible under 10 power hand lens; pH 4.9; clear smooth boundary; 10 to 13 cm. thick.
Bt <sub>2</sub>	25-33	Dark brown (10YR 4/3) when moist and brown (10YR 5/3) when dry; LS; weak fine sub-angular blocky; very friable and soft; plentiful fine vertical roots and plentiful medium and coarse horizontal roots; common very fine inped vesicular pores; clay bridging between sand grains visible under 10 power hand lens; pH 5.1; abrupt smooth boundary; 8 to 13 cm. thick.
Bm	33-65	Dark yellowish brown (10YR 4/4) when moist and yellowish brown (10YR 5/6) when dry; S; single grained; loose; few fine vertical roots and plentiful medium and coarse vertical roots; some cobble size stones at upper boundary; pH 5.2; gradual smooth boundary; 30 to 38 cm. thick.
BC	65-108	Yellowish brown (10YR 5/6) moist and dry; S; single grained; loose; plentiful medium and coarse vertical roots; pH 5.4; gradual smooth boundary; 38 to 50 cm. thick.
C	108-168+	Yellowish brown (10YR 5/5) when moist and yellowish brown to brownish yellow (10YR 5.5/6) when dry; S; single grained; loose; plentiful medium and coarse vertical roots; pH 5.4.



Profile Number W.C. 210

Horizon		Ahe	Ae	Bt <sub>1</sub>	Bt <sub>2</sub>	Bm	BC	C
Depth(cm)		0-5	5-15	15-25	25-33	33-65	65-108	108-168+
CHEMICAL ANALYSES								
pH		5.2	4.8	4.9	5.1	5.2	5.4	5.4
CaCO <sub>3</sub> Equiv.(%)		-	-	-	-	-	-	-
Org. C(%)		2.58	0.58	1.46	1.03	0.35	-	-
Exchange	H	6.61	2.05	7.18	5.94	2.70	1.61	1.24
Analysis	Ca	4.0	1.7	2.5	2.5	0.7	0.5	0.5
(meq/100 g)	Mg	1.3	0.2	1.3	1.6	0.3	0.5	0.2
	K	0.36	0.13	0.18	0.18	0.05	0.03	0.02
	Na	0.03	0.34	0.03	0.15	0.06	0.01	0.02
	TEC	4.9	3.2	11.2	10.0	2.7	1.6	1.0
Soluble	Ca	-	-	-	-	-	-	-
Salts	Mg	-	-	-	-	-	-	-
(meq/l)	Na	-	-	-	-	-	-	-
	SO <sub>4</sub>	-	-	-	-	-	-	-
EC(mmhos/cm)		-	-	-	-	-	-	-
PHYSICAL ANALYSES								
Particle	S	80	75	72	79	97	98	98
Size	Si	15	20	18	14	1	2	2
Analysis(%)	C	5	5	10	7	2	0	0
USDA Text. Class		LS	LS	SL	LS	S	S	S
Unified Rating		-	SW-SM	SW-SC	-	-	-	SP
Atterberg	LL	-	-	-	-	-	-	-
Limits	PI	-	-	-	-	-	-	-
	LI	-	-	-	-	-	-	-
Bulk	Db	-	-	1.12	-	-	-	-
Density(g/cc)	%M	-	-	10	-	-	-	-
Penetrometer	Ave	-	-	-	-	-	-	-
(kg/cm <sup>2</sup> )	Rge	-	-	-	-	-	-	-
% Nat. M		-	-	-	-	-	-	-
% Hygro. M		1.26	0.37	1.78	1.69	0.46	0.25	0.16
% 15 bar M		8	2	6	4	1	1	1
% 1/3 bar M		-	-	-	-	-	-	-
% 1/10 bar M		23	16	25	18	4	2	3
% Sat.. Cap.		-	-	-	-	-	-	-



**USDA** **UNIFIED**

GRAVEL		SAND SIZES					SILT		CLAY		
		VC	C	M	F	VF					
GRAVEL SIZES		SAND SIZES					FINES (SILT OR CLAY)				
COARSE	FINE	COARSE	MEDIUM	FINE							

**U.S. STANDARD SIEVE SIZES**

Sieve Size (mm)	Bt1 (%)	Ae (%)	C (%)
3" (76.2)	100	100	100
1 1/2" (38.1)	100	100	100
3/4" (19.0)	100	100	100
3/8" (9.5)	100	100	100
#4 (4.75)	100	100	100
#10 (2.0)	100	100	100
#20 (0.85)	100	100	100
#40 (0.425)	100	100	100
#60 (0.25)	100	100	100
#100 (0.15)	100	100	100
#200 (0.075)	10	5	2
#325 (0.045)	5	2	1

**PERCENT FINER THAN**

**U.S. STANDARD SIEVE SIZES**

**MILLIMETRES**

**INCHES**

**Legend:**

- $D_{10}$  = \_\_\_\_\_ MM.
- $D_{30}$  = \_\_\_\_\_ MM.
- $D_{60}$  = \_\_\_\_\_ MM.
- $C_U$  = \_\_\_\_\_
- $C_C$  = \_\_\_\_\_



Classification

Sub-group: Degraded Dystric Brunisol  
 Series: Nestow (Nt)  
 7th Approximation Equivalent: Spodic Cryopsamment  
 Profile Number: W.C. 191

Parent Material: Alluvial sand  
 Topography: d slope; E aspect  
 Elevation above Lake Level: 12.7 metres  
 Drainage: Rapid

Vegetation and Cover Estimates:

Tree Canopy: B. papyrifera (25%), P. tremuloides (50%).  
 Shrubs and Half Shrubs: C. stolonifera (10%), Rosa spp. (10%),  
R. glandulosum, R. pubescens, Salix spp.,  
R. strigosus, A. alnifolia.  
 Herbs: A. rubra, A. nudicaulis (50%), G. borealis,  
G. trifolium, Aster spp., E. angustifolia,  
Lathyrus spp.  
 Grasses: Few species.





<u>HORIZON</u>	<u>DEPTH (cm.)</u>	<u>DESCRIPTION</u>
L-H	5-0	Partially and semi-decomposed leaf matter and woody fragments.
Ahe	0-13	Very dark brown (7.5YR 2/2) when moist and dark brown (10YR 3/3) when dry; LS; single grained; very friable and soft; plentiful fine vertical roots and abundant medium and coarse horizontal roots; many very fine vesicular pores; pH 6.2; clear wavy boundary; 3 to 13 cm. thick.
Ae	13-25	Dark brown to brown (7.5YR 4/3) when moist and brown to pale brown (10YR 5.5/3) when dry; LS; single grained; loose and soft; plentiful fine vertical roots and abundant medium and coarse horizontal roots; many very fine vesicular pores; pebble layer at lower boundary; pH 5.8; clear smooth boundary; 10 to 15 cm. thick.
Bm	25-50	Yellowish red (5YR 4/6) when moist and strong brown (7.5YR 4/6) when dry; S; single grained; loose and soft; few fine vertical roots and few medium and coarse vertical roots; many very fine vesicular pores; pH 6.5; gradual smooth boundary; 20 to 40 cm. thick.
BC	50-135	Dark yellowish brown (10YR 4/6) when moist and yellowish brown (10YR 5/6) when dry; S; single grained; loose and soft; plentiful medium and coarse vertical roots and few medium horizontal roots; many very fine vesicular pores; pH 6.7; clear smooth boundary; 75 to 95 cm. thick.
C	135-160	Yellowish brown (10YR 5/6) when moist and brownish yellow (10YR 6/6) when dry; S; single grained; loose and soft; very few roots; many very fine vesicular pores; very weakly cemented; gravelly and cobbly at boundary; pH 7.0; abrupt smooth boundary; 23 to 28 cm. thick.
II Ck	160-180+	Dark clay till; not described or sampled.



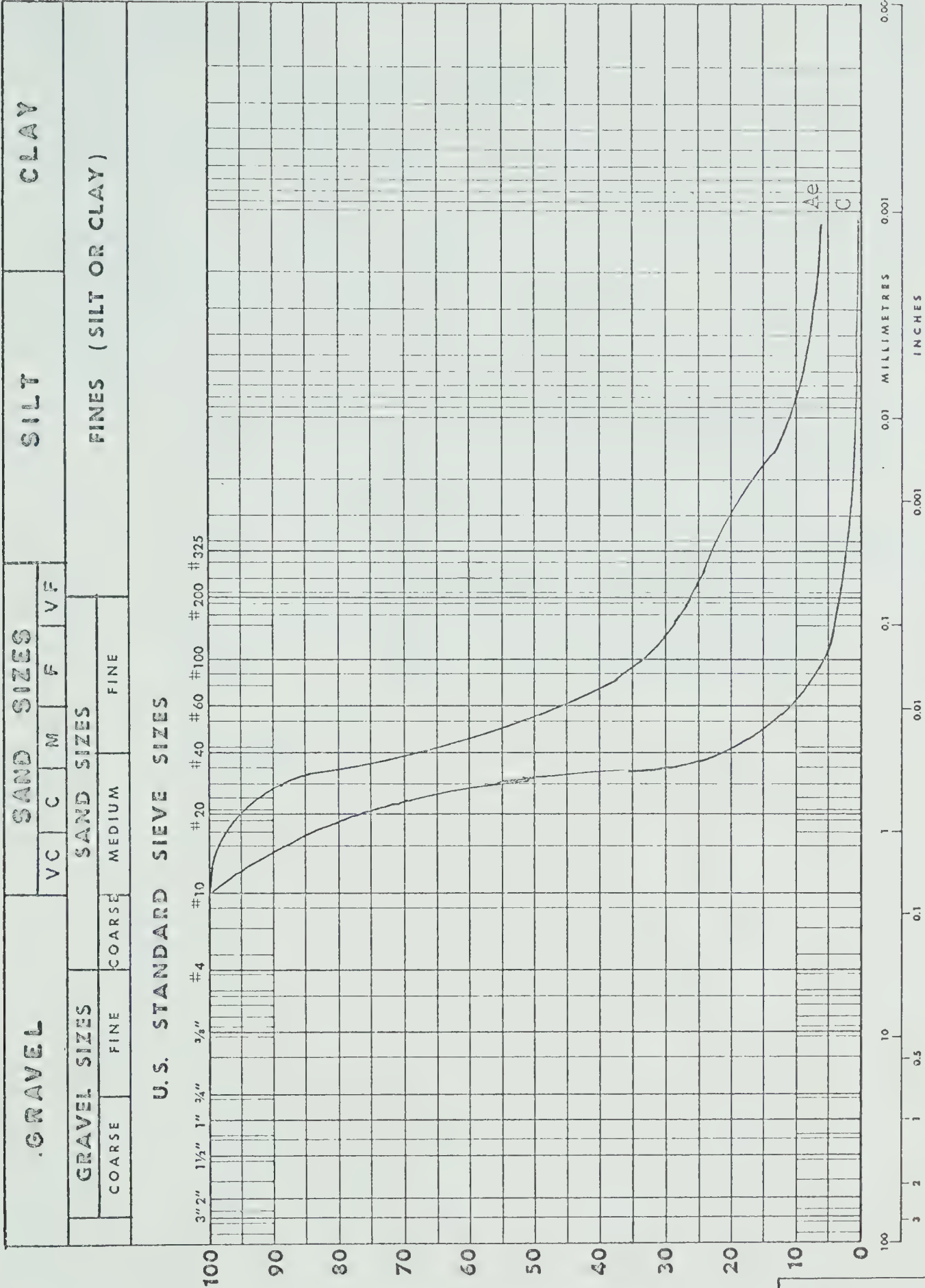
Profile Number W.C. 191

Horizon		Ahe	Ae	Bm	BC	C
Depth(cm)		0-13	13-25	25-50	50-135	135-160+
CHEMICAL ANALYSES						
pH		6.2	5.8	6.5	6.7	7.0
CaCO <sub>3</sub> Equiv.(%)		-	-	-	-	0.10
Org. C(%)		1.70	0.42	0.26	-	-
Exchange	H	3.19	2.55	1.24	0.58	0.34
Analysis	Ca	4.2	2.2	1.7	1.5	1.2
(meq/100 g)	Mg	2.0	1.2	1.2	0.4	0.2
	K	0.36	0.16	0.05	0.04	0.04
	Na	0.02	0.22	0.04	0.01	0.01
	TEC	8.4	5.1	2.7	1.4	1.0
Soluble	Ca	-	-	-	-	-
Salts	Mg	-	-	-	-	-
(meq/l)	Na	-	-	-	-	-
	SO <sub>4</sub>	-	-	-	-	-
EC(mmhos/cm <sup>2</sup> )		-	-	-	-	-
PHYSICAL ANALYSES						
Particle	S	78	75	95	99	97
Size	Si	17	18	3	1	2
Analysis(%)	C	5	7	2	0	1
USDA Text. Class		LS	LS	S	S	S
Unified Rating		-	SW-SM	-	-	SP
Atterberg	LL	-	-	-	-	-
Limits(%)	PI	-	-	-	-	-
	LI	-	-	-	-	-
Bulk	Db	-	-	-	-	-
Density(g/cc)	%M	-	-	-	-	-
Penetrometer	Ave	-	-	-	-	-
(kg/cm <sup>2</sup> )	Rge	-	-	-	-	-
% Nat. M		-	-	-	-	-
% Hygro. M		1.26	0.69	0.41	0.20	0.04
% 15 bar M		4	3	1	1	1
% 1/3 bar M		-	-	-	-	-
% 1/10 bar M		19	18	6	4	2
% Sat. Cap.		-	-	-	-	-



USDA

UNIFIED





Classification

Sub-group: Degraded Dystric Brunisol  
 Series: Edwand (Ed)  
 7th Approximation Equivalent: Spodic Cryopsamment  
 Profile Number: W.C. 230

Parent Material: Outwash  
 Topography: d slope; S aspect  
 Elevation above Lake Level: 6.6 metres  
 Drainage: Well to rapid

Vegetation and Cover Estimates:

Tree Canopy: P. glauca (20%), P. tremuloides (10%),  
A. balsamea (15%), B. papyrifera (5%).

Shrubs and Half Shrubs: C. stolonifera, V. edule,  
L. borealis, Rosa spp.

Herbs: A. nudicaulis, R. pubescens, M. canadense,  
C. canadensis, G. borealis, M. nuda, F.  
virginiana, V. adunca, G. trifolium.

Mosses: Ptilium spp. and Hylocomium spp.



# AII T-2

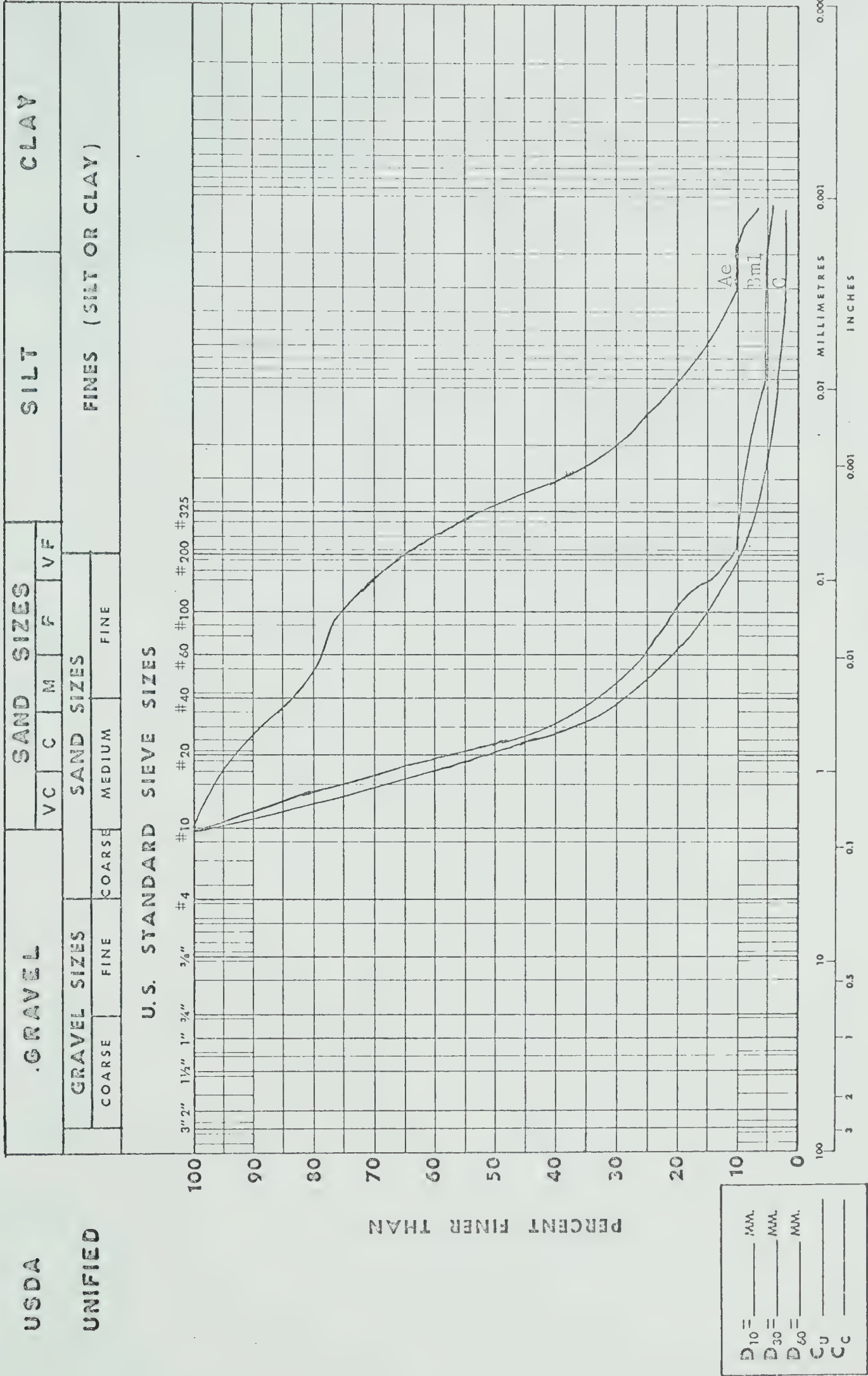
<u>HORIZON</u>	<u>DEPTH (cm.)</u>	<u>DESCRIPTION</u>
L-F	8-0	Partially decomposed leaf matter and woody fragments.
Ahe	0-5	Very dark grayish brown (10YR 3/2) when moist and brown (10YR 4.5/3) when dry; SL; very weak medium platy; very friable and soft; plentiful fine, medium, and coarse horizontal roots; many very fine inped vesicular pores; pH 5.3; clear smooth boundary; 5 to 10 cm. thick.
Ae	5-20	Brown (10YR 5/3) when moist and pale brown (10YR 6/3) when dry; SL; weak medium platy; very friable and soft; abundant fine, medium, and coarse horizontal roots; many very fine inped vesicular pores; cobbles in lower 5 cm.; pH 5.1; abrupt smooth boundary; 8 to 15 cm. thick.
Bm <sub>1</sub>	20-43	Dark brown to brown (7.5YR 4/4) when moist and yellowish brown (10YR 5/4) when dry; S; single grained; loose; plentiful fine, medium, and coarse vertical roots; many cobbles; pH 5.1; gradual irregular boundary; 10 to 38 cm. thick.
Bm <sub>2</sub>	43-78	Strong brown (10YR 5/6) when moist and brown (10YR 5/4) when dry; S; single grained; loose; few fine, medium and coarse vertical roots; very gravelly and cobbly; pH 5.2; abrupt smooth boundary; 18 to 35 cm. thick.
II Bm	78-108	Yellowish brown (10YR 5/7) when moist and yellowish brown (10YR 5/6) when dry; S; single grained; loose; no roots; not gravelly; pH 6.2; abrupt smooth boundary; 25 to 35 cm. thick.
C	108-138+	Yellowish brown to dark yellowish brown (10YR 4.5/6) when dry; S; gravelly and cobbly outwash; pH 5.8.



Profile Number W.C. 230

Horizon		Ahe	Ae	Bm <sub>1</sub>	Bm <sub>2</sub>	IIBm	C
Depth(cm)		0-5	5-20	20-43	43-78	78-108	108-138+
CHEMICAL ANALYSES							
pH		5.3	5.1	5.1	5.2	6.2	5.8
CaCO <sub>3</sub> Equiv.(%)		-	-	-	-	-	-
Org. C(%)		1.36	0.68	1.03	0.32	0.02	-
Exchange	H	4.56	3.70	1.97	2.38	0.85	1.17
Analysis	Ca	3.0	1.5	2.0	1.5	1.2	1.0
(meq/100 g)	Mg	0.8	2.3	1.4	1.1	0.7	2.1
	K	0.45	0.22	0.10	0.10	0.07	0.17
	Na	0.03	0.04	0.07	0.01	0.01	0.02
	TEC	8.7	6.5	5.2	3.8	1.9	3.5
Soluble	Ca	-	-	-	-	-	-
Salts	Mg	-	-	-	-	-	-
(meq/l)	Na	-	-	-	-	-	-
	SO <sub>4</sub>	-	-	-	-	-	-
EC(mmhos/cm)		-	-	-	-	-	-
PHYSICAL ANALYSES							
Particle	S	44	52	90	92	96	92
Size	Si	46	38	5	5	3	6
Analysis(%)	C	10	10	5	3	1	2
USDA Text. Class		SL	SL	S	S	S	S
Unified Rating		-	-	SW-SM	-	-	SW-SM
Atterberg	LL	-	-	-	-	-	-
Limits(%)	PI	-	-	-	-	-	-
	LI	-	-	-	-	-	-
Bulk	Db	1.12	-	-	-	-	-
Density(g/cc)	%M	15	-	-	-	-	-
Penetrometer	Ave	-	-	-	-	-	-
(kg/cm <sup>2</sup> )	Rge	-	-	-	-	-	-
% Nat. M		-	-	-	-	-	-
% Hygro. M		2.24	1.14	0.95	0.68	0.19	0.43
% 15 bar M		5	4	3	2	1	2
% 1/3 bar M		15	15	4	4	2	2
% 1/10 bar M		28	24	5	7	3	4
% Sat. Cap.		-	-	-	-	-	-







Classification

Sub-group: Rego Humic Gleysol  
 Series: Lacroix (Lx)  
 7th Approximation Equivalent: Calcic Cryaquoll  
 Profile Number: W.C. 237

Parent Material: Alluvium / Lacustrine / Dark till  
 Topography: c slope; E aspect  
 Elevation above Lake Level: 2.4 metres  
 Drainage Class: Poor

Vegetation and Cover Estimates:

Tree Canopy: P. balsamifera (55%), B. papyrifera (20%).  
 Shrubs: A. alnifolia, C. stolonifera, V. edule (20%),  
Salix spp. (20%), Rosa spp., R. glandulosum,  
L. borealis (5%).  
 Herbs: P. asarifolia, C. canadensis, A. nudicaulis  
 (5%), G. triflorum, Aster spp., R. pubescens,  
M. paniculata, F. virginiana, Geranium spp.



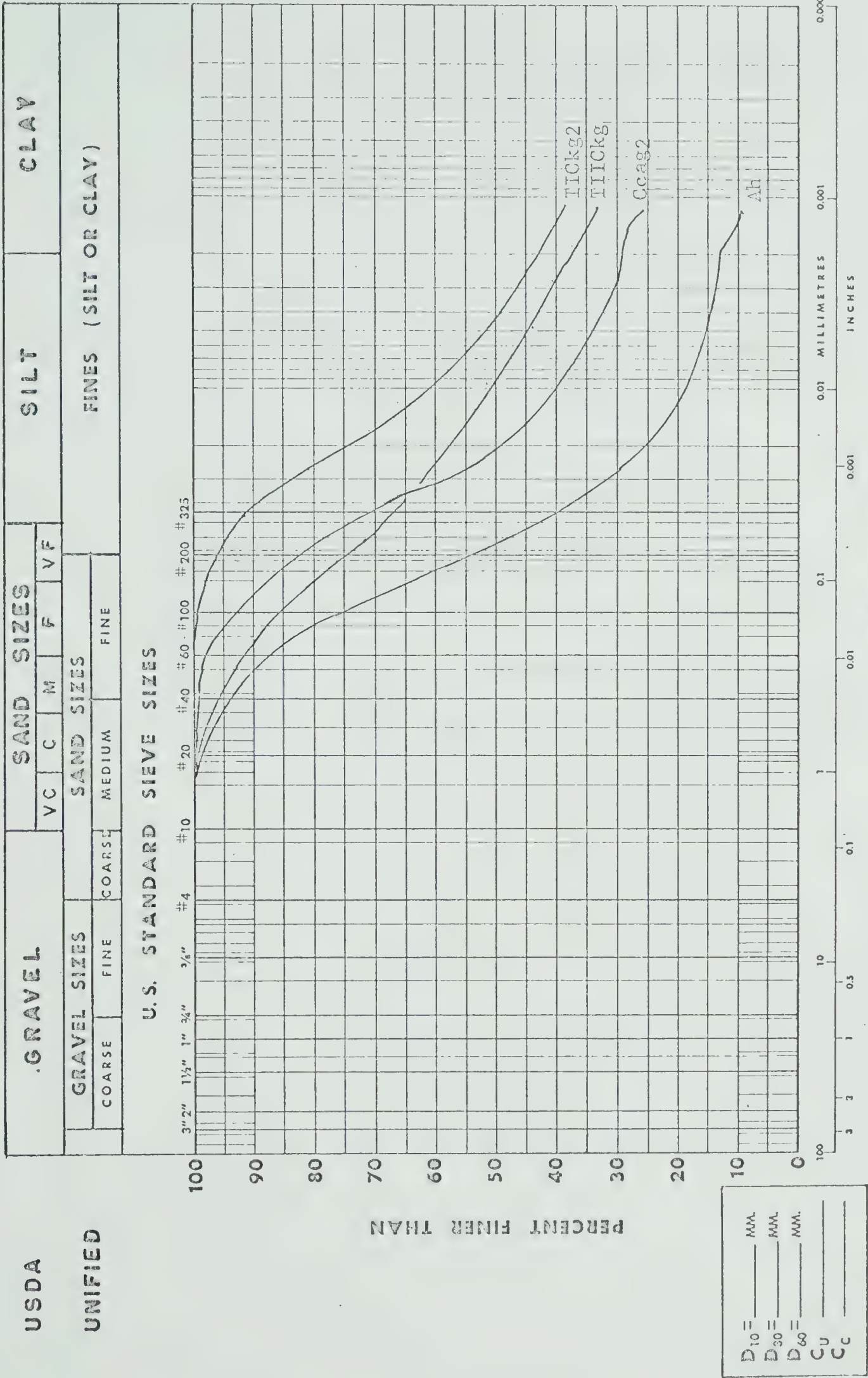
<u>HORIZON</u>	<u>DEPTH (cm.)</u>	<u>DESCRIPTION</u>
L-F	5-0	Semi-decomposed leaf matter, bits of charcoal, woody fragments.
Ah	0-25	Black (10YR 1.7/1) when moist and very dark brown (10YR 2/2) when dry; SL; weak medium platy (depositional); very friable and soft; abundant fine, medium, and coarse roots in upper 10 cm. and plentiful fine, medium, and coarse roots in lower 15 cm.; many very fine vesicular and interstitial pores; pH 8.1; abrupt wavy boundary; 23 to 50 cm. thick.
Ckg <sub>1</sub>	25-38	Gray to dark gray (2.5Y 4.5/1) matrix and yellowish red (5YR 4/6) mottles when moist and light brownish gray (10YR 6/2) matrix and yellowish brown (10YR 5/6) mottles when dry; SiL; weak to moderate medium platy (depositional); friable and slightly hard; plentiful fine vertical roots and abundant medium and coarse random roots; many very fine vesicular and interstitial pores; common fine distinct and prominent mottles; strongly effervescent; pH 7.7; clear smooth boundary; 8 to 15 cm. thick.
Ckg <sub>2</sub>	38-70	Dark gray (2.5Y 4/1) matrix and dark yellowish brown (10YR 4/6) mottles when moist and gray (10YR 6/1) matrix and yellowish brown (10YR 5/7) mottles when dry; CL; weak medium platy (depositional); friable and slightly hard; plentiful fine vertical roots and abundant medium and coarse horizontal and vertical roots; many very fine vesicular and interstitial pores; many fine faint to distinct mottles; strongly effervescent; pH 7.4; clear smooth boundary; 30 to 35 cm. thick.
II Ccag	70-95	Dark gray (2.5Y 4/1) matrix and dark yellowish brown (10YR 3/4) mottles when moist and gray (10YR 5.5/1) matrix and reddish yellow (7.5YR 5/7) mottles when dry; SiC; moderate fine angular blocky; firm and hard; few fine vertical roots and plentiful medium and coarse vertical roots; common very fine vesicular and interstitial pores; common fine faint mottles; weakly effervescent; pH 7.5; clear smooth boundary; 18 to 30 cm. thick.
II Ckg	95-113	Dark gray (2.5Y 4/1) matrix and brown to dark brown (7.5YR 4/4) mottles when moist and gray (10YR 5.5/1) matrix and yellowish red (5YR 5/7) mottles when dry; SiC; moderate fine angular blocky; friable and hard; few fine vertical roots and very few medium roots; common very fine vesicular and interstitial pores; many fine distinct mottles; slightly effervescent; pH 7.5; clear smooth boundary; 13 to 25 cm. thick.
III Ckg	113-150+	Dark gray to very dark gray (2.5Y 3.5/1) matrix and dark yellowish brown (10YR 3.5/4) mottles when moist and gray (10YR 5/1) matrix and strong brown (7.5YR 5/6) mottles when dry; CL; moderate fine angular blocky; firm and hard; no roots; common very fine vesicular and interstitial pores; many fine faint to distinct mottles; slightly effervescent; pH 7.5.



Profile Number W.C. 237

Horizon		Ah	C kg <sub>1</sub>	C kg <sub>2</sub>	IICcag	IICkg	IIICkg
Depth(cm)		0-25	25-38	38-70	70-95	95-113	113-150+
CHEMICAL ANALYSES							
pH		8.1	7.7	7.4	7.5	7.5	7.5
CaCO <sub>3</sub> Equiv.(%)		0.42	0.46	0.60	15.46	2.02	1.72
Org. C(%)		3.49	-	-	-	-	-
Exchange	H	-	-	-	-	-	-
Analysis	Ca	-	-	17.3	17.3	16.3	11.9
(meq/100 g)	Mg	-	-	7.2	6.7	7.0	6.8
	K	-	-	0.50	0.64	0.63	0.49
	Na	-	-	1.59	1.78	1.59	0.96
	TEC	-	-	14.7	21.6	20.2	15.7
Soluble	Ca	-	-	-	-	-	-
Salts	Mg	-	-	-	-	-	-
(meq/l)	Na	-	-	-	-	-	-
	SO <sub>4</sub>	-	-	-	-	-	-
EC(mmhos/cm)		-	-	-	-	-	-
PHYSICAL ANALYSES							
Particle	S	58	20	27	-	8	32
Size	Si	29	58	44	-	50	30
Analysis(%)	C	13	22	29	-	42	38
USDA Text. Class		SL	SiL	CL	-	SiC	CL
Unified Rating		-	CL-ML	-	-	CL	CL
Atterberg	LL	28	29	-	-	44	34
Limits(%)	PI	-	7	-	-	24	14
	LI	-	0	-	-	-	-
Bulk	Db	1.24	1.40	-	-	-	-
Density(g/cc)	%M	25	22	-	-	-	-
Penetrometer	Ave	-	-	-	-	-	-
(kg/cm <sup>2</sup> )	Rge	-	-	-	-	-	-
% Nat. M		-	-	-	-	-	-
% Hygro. M		4.11	2.72	3.04	8.31	7.01	5.35
% 15 bar M		4	8	10	15	16	12
% 1/3 bar M		21	21	23	31	31	23
% 1/10 bar M		-	-	-	-	-	-
% Sat. Cap.		-	-	-	-	-	-























## LEGEND

	Grandin (Gn)	: Orthic Gray Luvisol developed on very dark grayish brown, fine textured, glacial till.
	Winston (Ws)	: Orthic Dark Gray Luvisol developed on very dark grayish brown, fine textured, glacial till.
	Lac La Biche (Lb)	: Gleyed Dark Gray Luvisol developed on very dark grayish brown, fine textured, glacial till.
	Athabasca (Ah)	: Orthic Gray Luvisol developed on dark brown, medium textured, glacial till.
	Cresmont (Ct)	: Orthic Dark Gray Luvisol developed on very dark grayish brown, fine textured, glacial till.
	Miquelon (Mq)	: Orthic Gray Luvisol developed on fine textured lacustrine deposits, overlying glacial till at less than 90 cm.
	Red Fox (Rf)	: Gleyed Dark Gray Luvisol developed on medium textured alluvial lacustrine deposits.
	Rich Lake (Rl)	: Gleyed Dark Gray Luvisol developed on medium textured alluvial lacustrine deposits.
	Culp (Cu)	: Orthic Gray Luvisol developed on coarse textured aeolian and/or alluvial deposits.
	Edward (Ed)	: Degraded Dystric Brunisol developed on coarse textured outwash deposits.
	Downing (Dw)	: Degraded Dystric Brunisol developed on coarse textured outwash deposits.
	Snipe (Sn)	: Low Humic Eluviated Gleysol developed on fine textured lacustrine deposits.
	Kenzie Complex (Kz)	: Terric Fibrisols having Of and Oe horizons, with or without thin layers of peat, moss, and woody plant remains.
	Eaglesham Complex (Eg)	: Terric Fibrisols, Mesisols, and Humisols with or without thin layers of peat, moss, and woody plant remains, 10 to 150 cm. in thickness that consist of organic material.
	Nedley (Ny)	: Orthic Regosol developed on recently deposited fine and medium gravels.
	Outwash Boulders (O.B.)	: Few to many cobbles and boulders, with organic material, in the soil profile.
	Peaty (P-)	: Any soil with less than 30 cm. of peat or organic material.

0 600 1200 1800 2400 3000

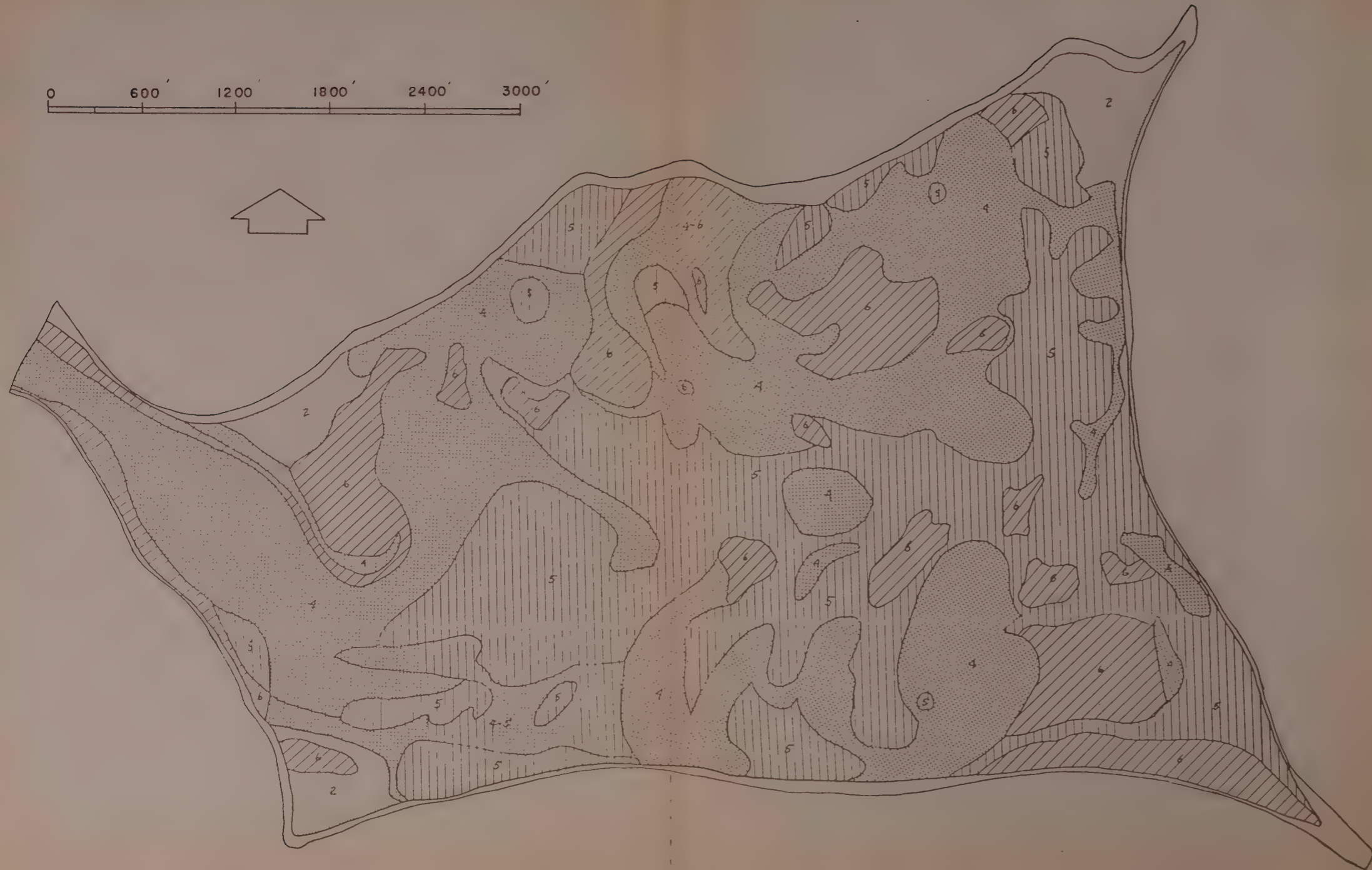
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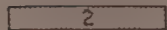


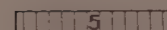

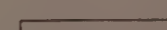




SIR WINSTON CHURCHILL  
PROVINCIAL PARK  
SOIL LIMITATIONS FOR  
CAMPING AREAS

0 600' 1200' 1800' 2400' 3000'



	NONE
	SLIGHT
	SLIGHT-MODERATE
	MODERATE
	MODERATE-SEVERE
	SEVERE
	NOT RATED



SIR WINSTON CHURCHILL  
PROVINCIAL PARK  
SOIL LIMITATIONS FOR  
PLAYGROUND AREAS

0 600' 1200' 1800' 2400' 3000'



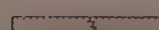
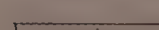





	NONE
	SLIGHT
	SLIGHT-MODERATE
	MODERATE
	MODERATE-SEVERE
	SEVERE
	NOT RATED

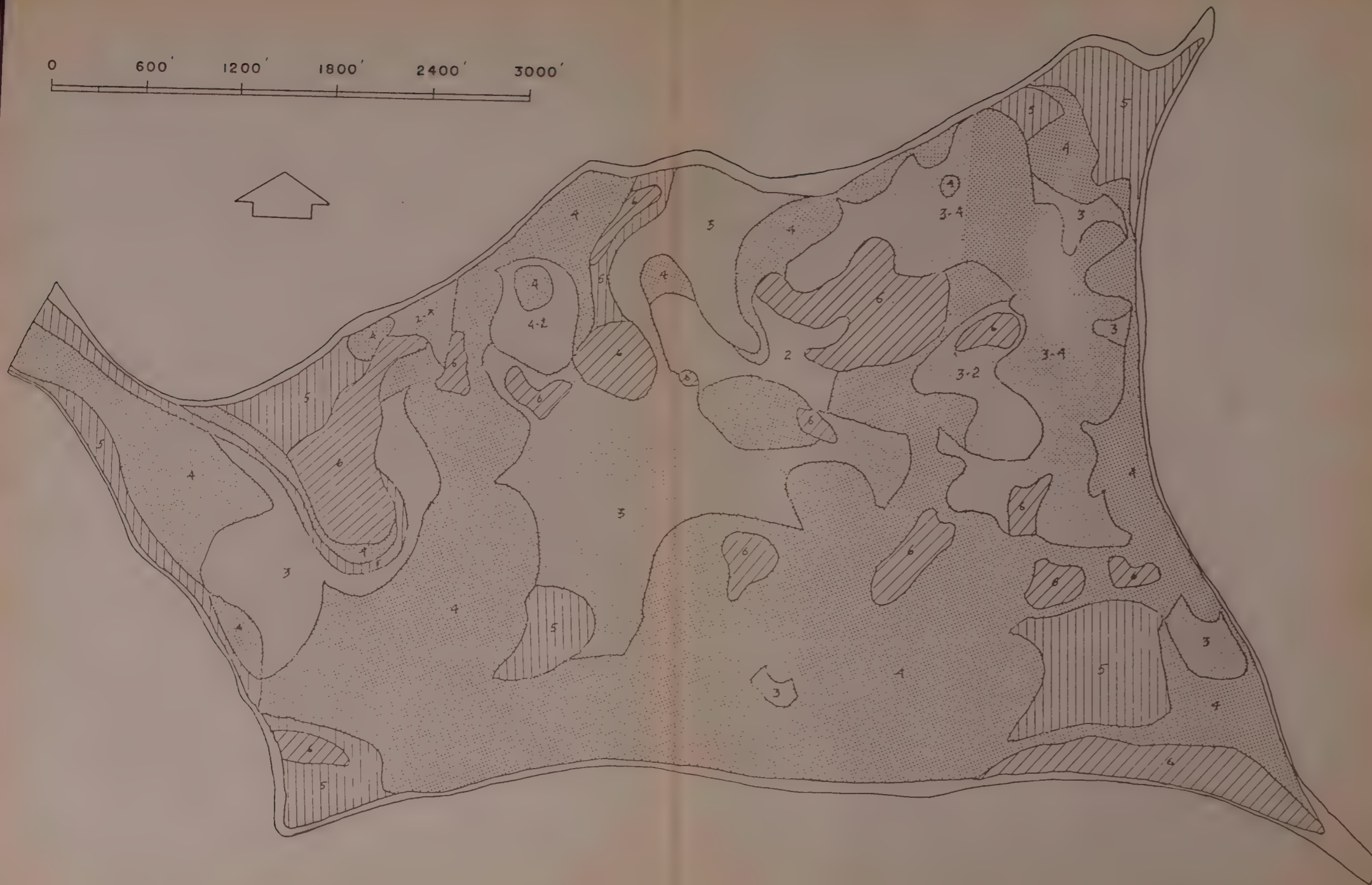
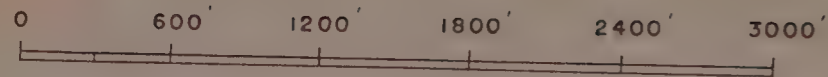


# SIR WINSTON CHURCHILL PROVINCIAL PARK SOIL LIMITATIONS FOR PICNIC AREAS



-  NONE
-  SLIGHT
-  SLIGHT-MODERATE
-  MODERATE
-  MODERATE-SEVERE
-  SEVERE
-  NOT RATED



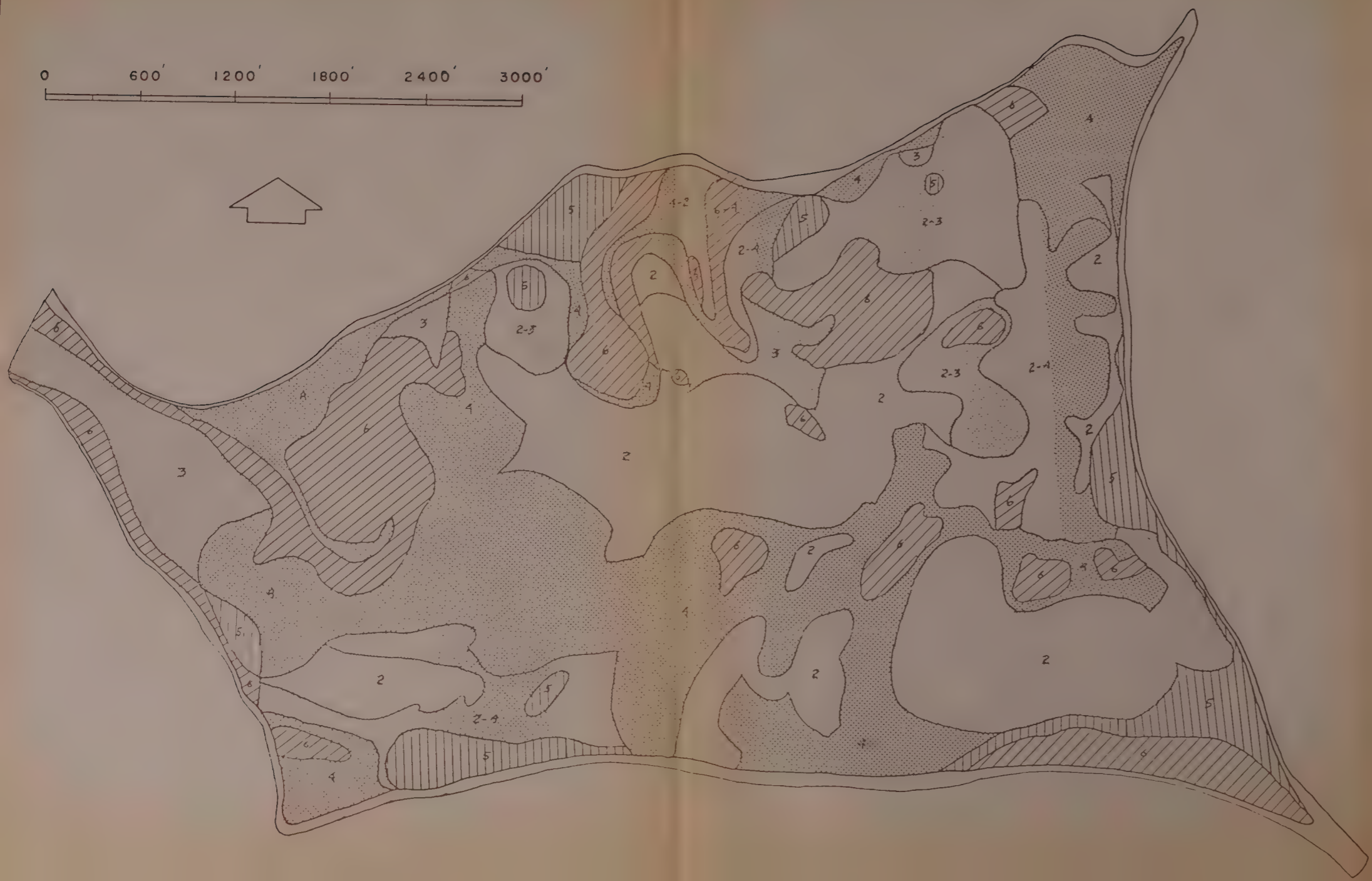
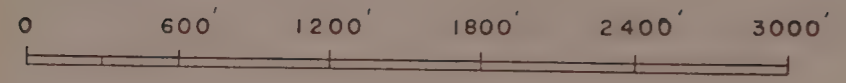


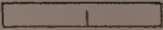


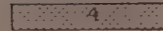
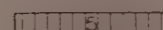


# SIR WINSTON CHURCHILL PROVINCIAL PARK SOIL LIMITATIONS FOR HIKING TRAILS

1	NONE
2	SLIGHT
3	SLIGHT-MODERATE
4	MODERATE
5	MODERATE-SEVERE
6	SEVERE
	NOT RATED



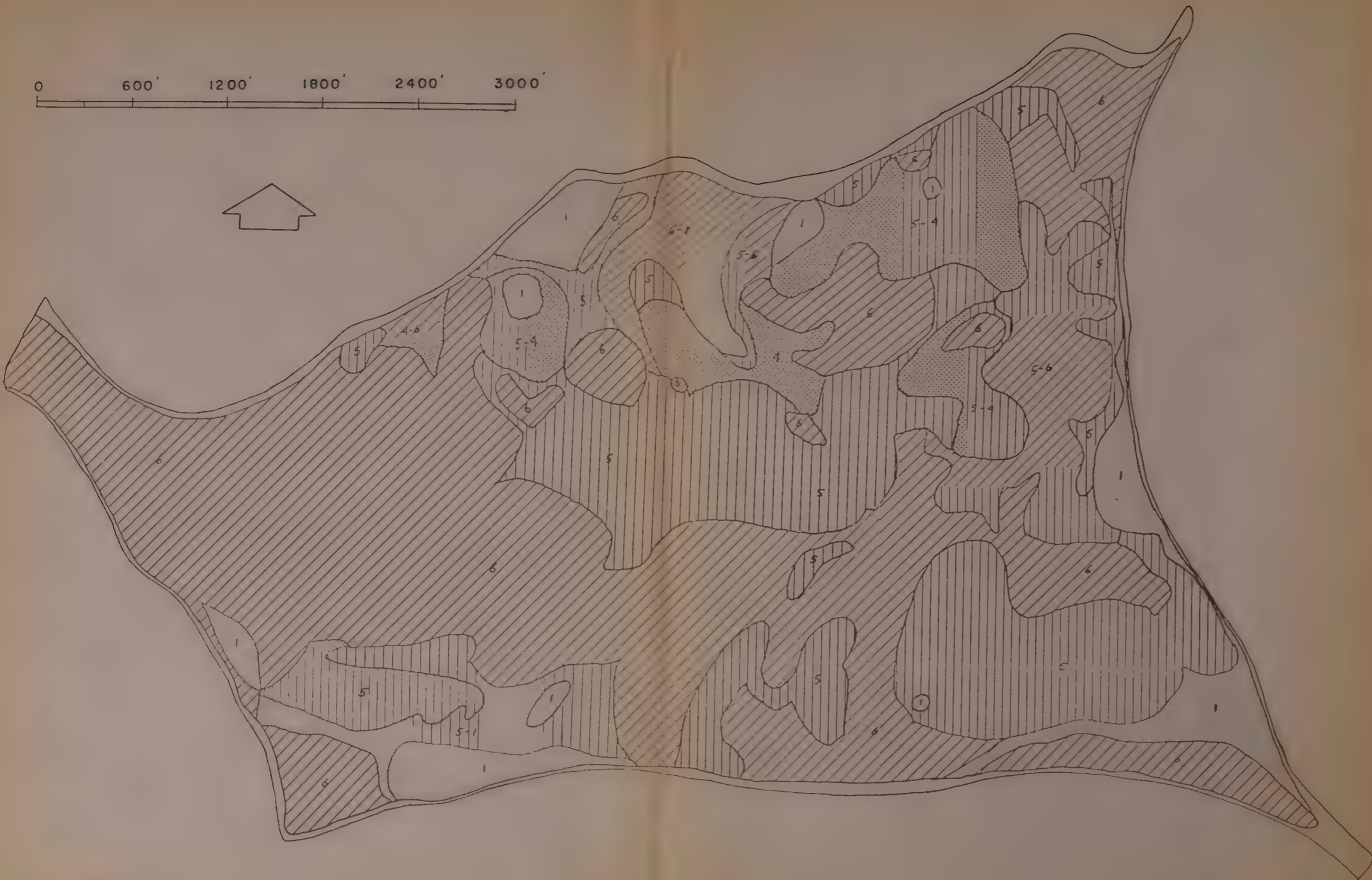
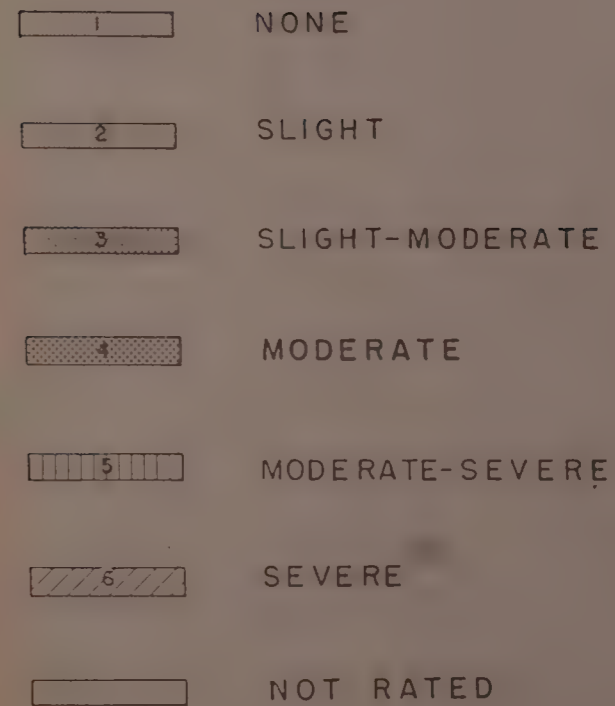
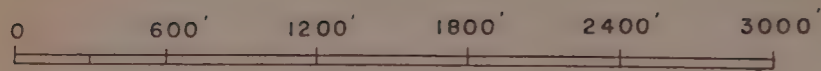
SIR WINSTON CHURCHILL  
 PROVINCIAL PARK  
 SOIL LIMITATIONS FOR  
 BUILDINGS



- |   |                 |
|---|-----------------|
|    | NONE            |
|    | SLIGHT          |
|    | SLIGHT-MODERATE |
|    | MODERATE        |
|  | MODERATE-SEVERE |
|  | SEVERE          |
|  | NOT RATED       |



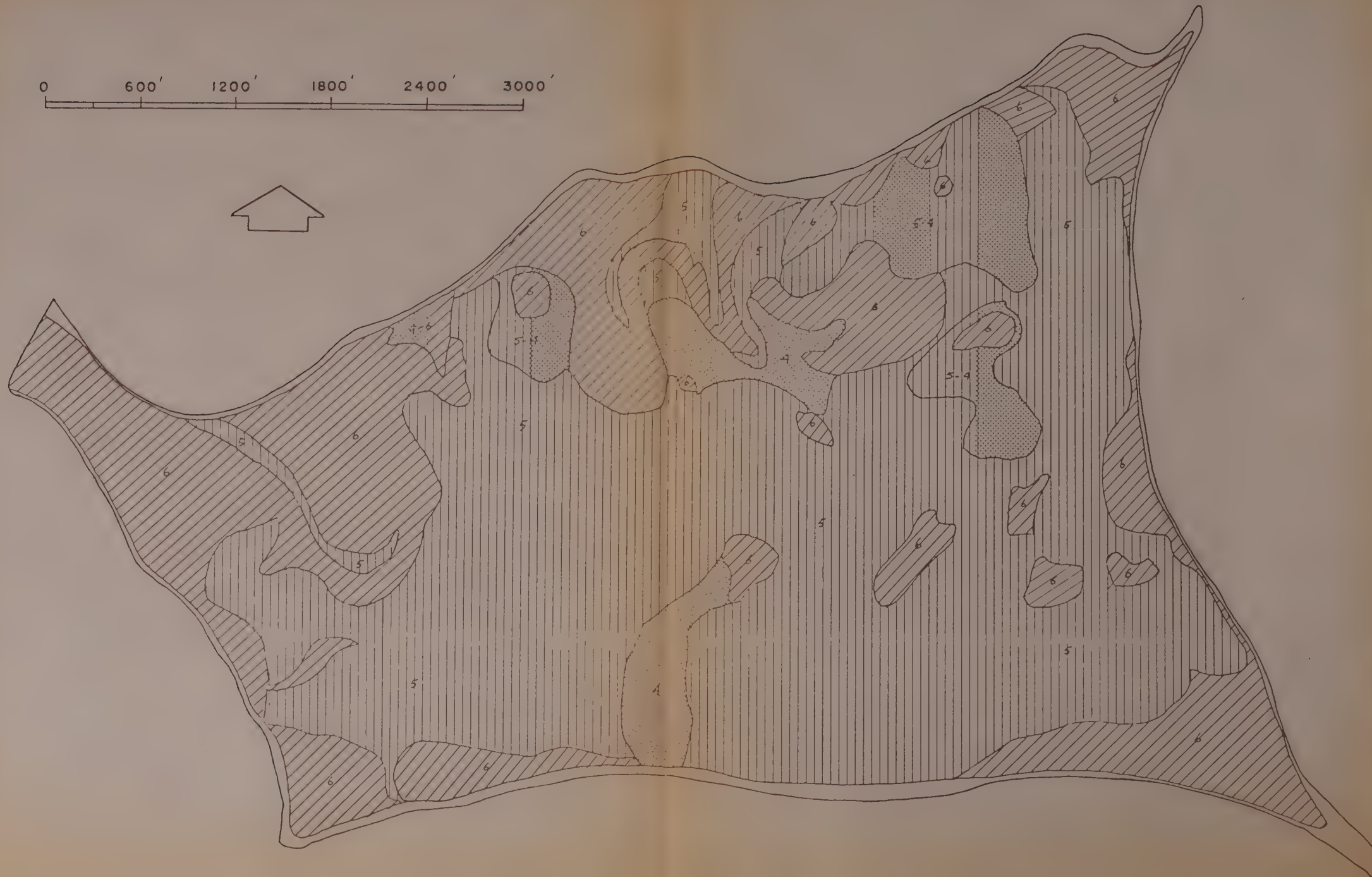
# SIR WINSTON CHURCHILL PROVINCIAL PARK SOIL LIMITATIONS FOR ROADS





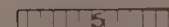






SIR WINSTON CHURCHILL  
PROVINCIAL PARK  
OIL LIMITATIONS FOR  
SEWAGE DISPOSAL

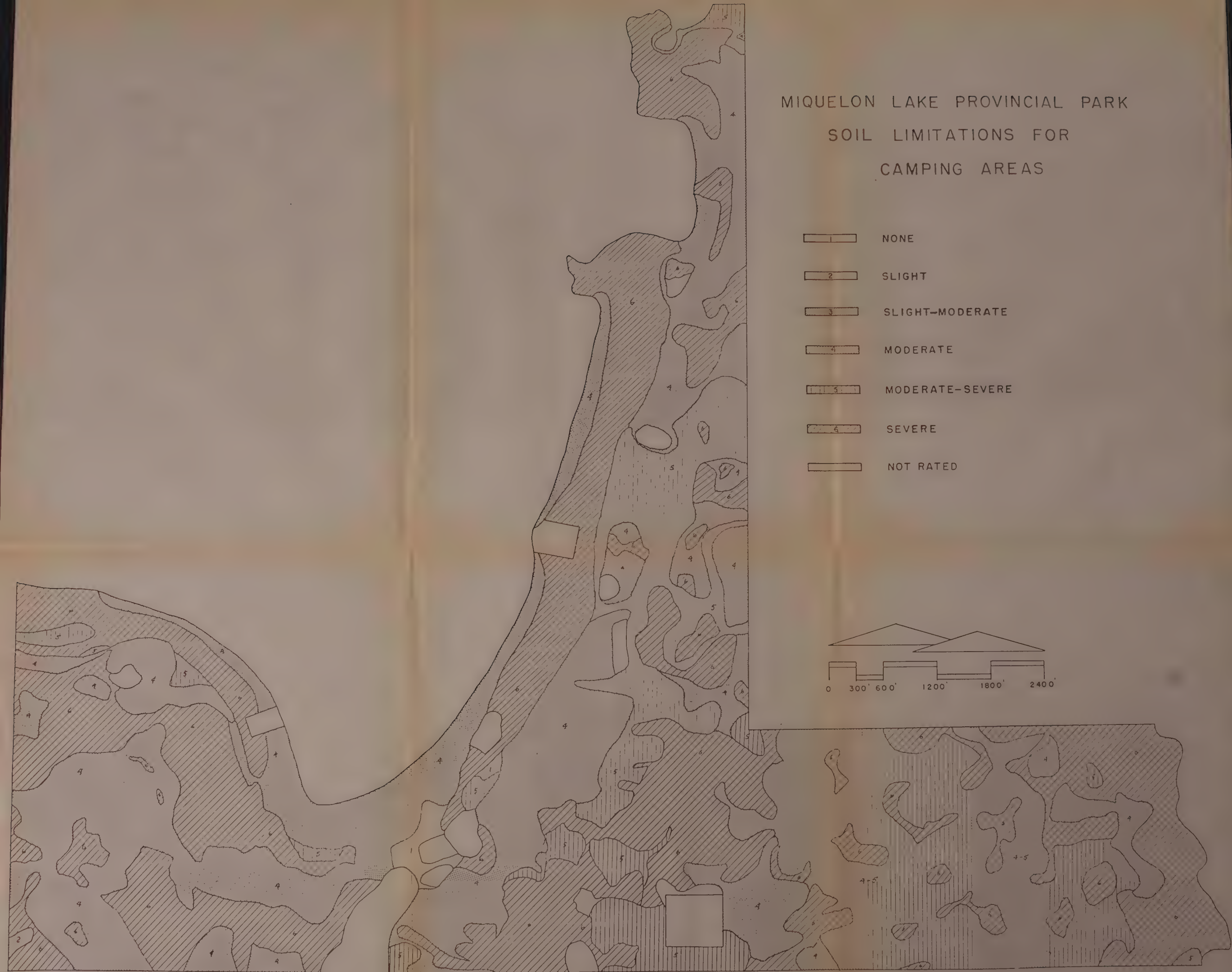
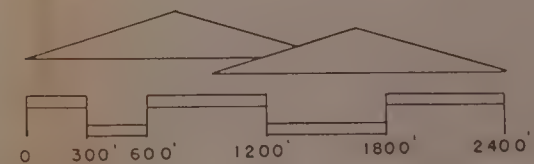
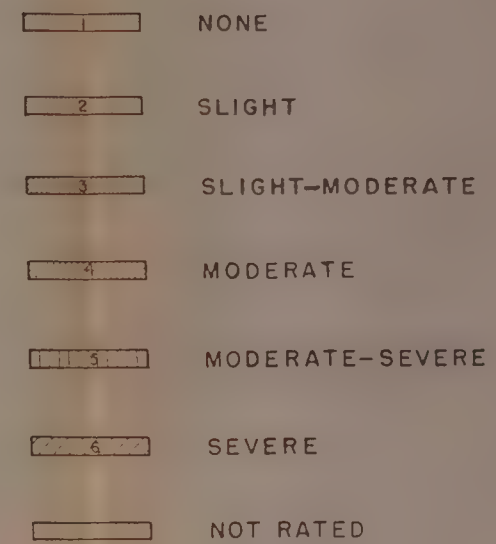
0 600' 1200' 1800' 2400' 3000'



	NONE
	SLIGHT
	SLIGHT-MODERATE
	MODERATE
	MODERATE-SEVERE
	SEVERE
	NOT RATED

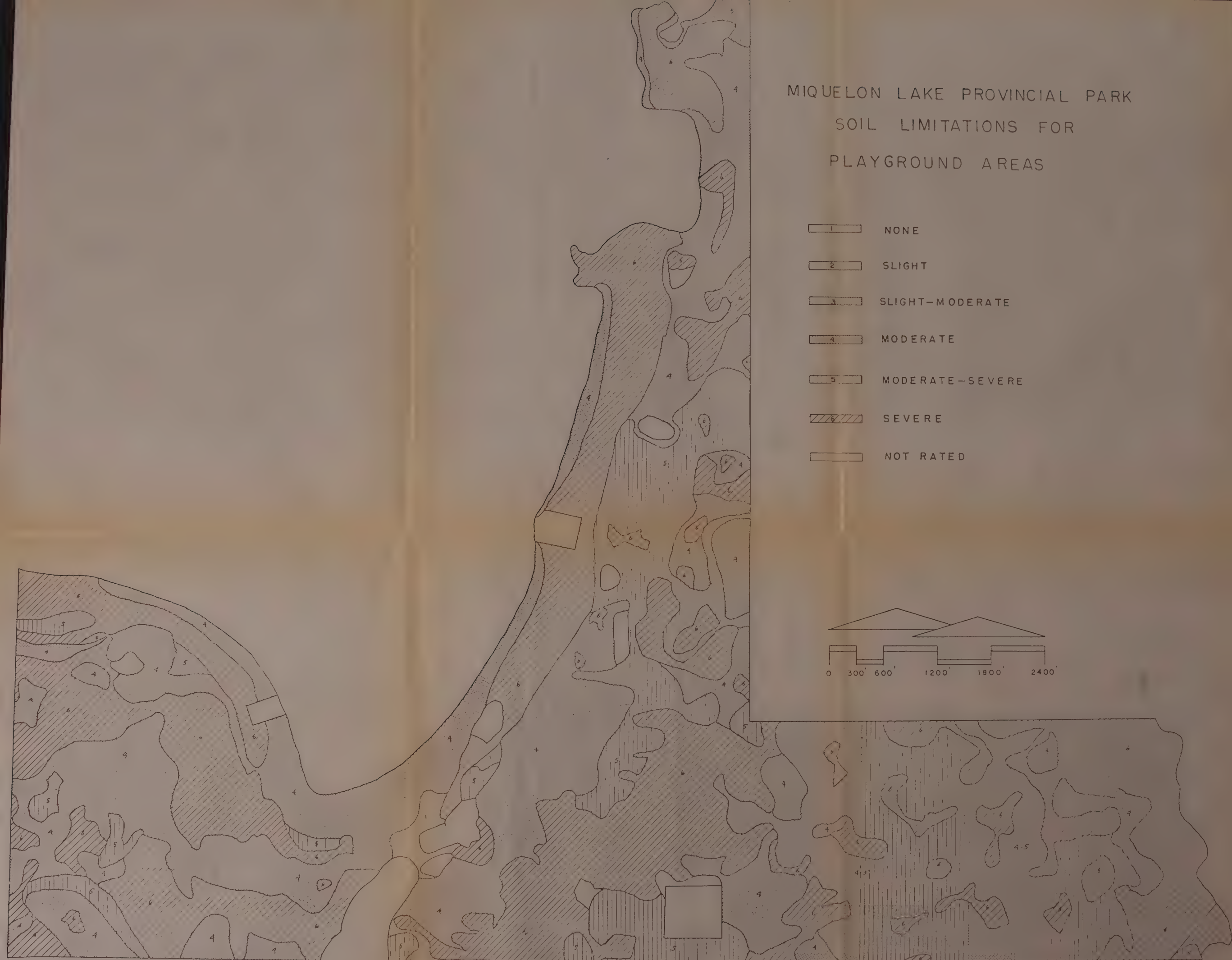
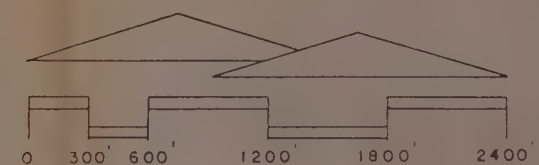
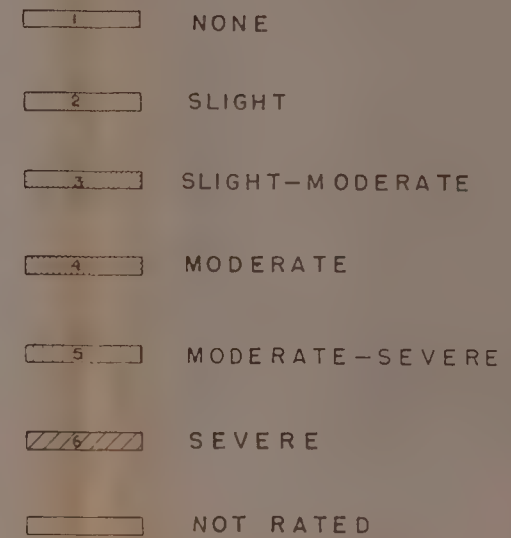


MIQUELON LAKE PROVINCIAL PARK  
SOIL LIMITATIONS FOR  
CAMPING AREAS



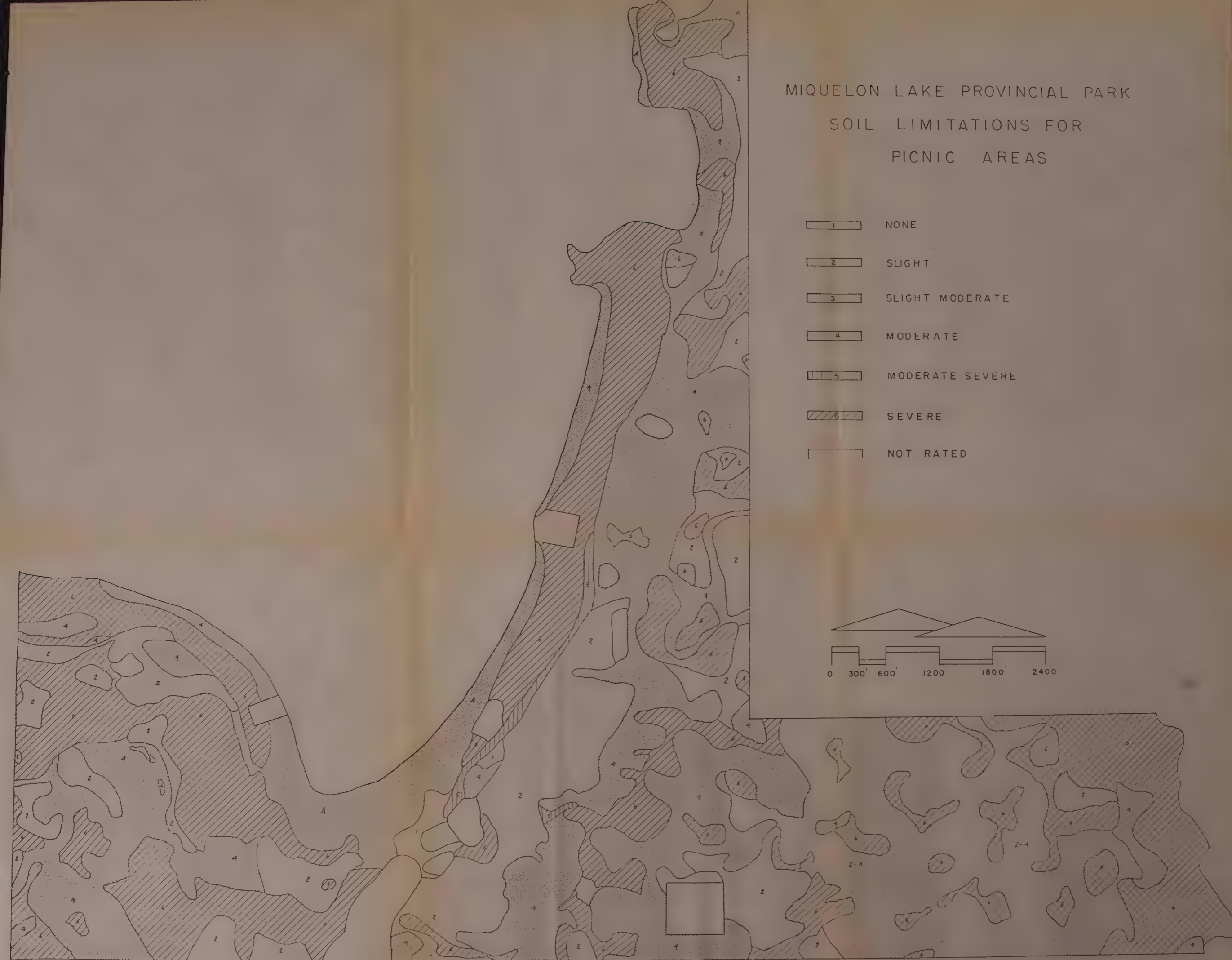
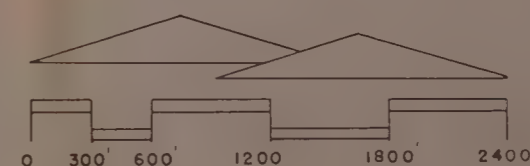
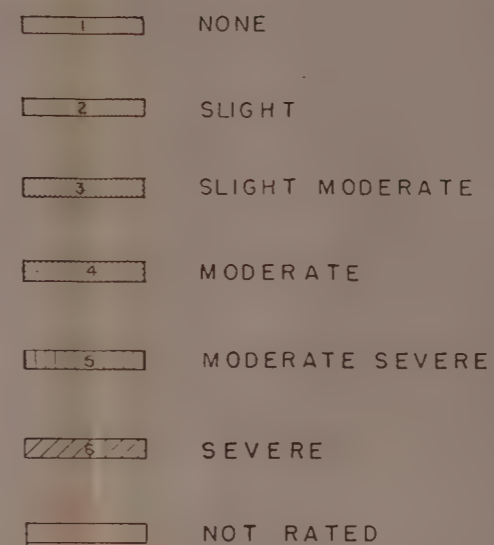


MIQUELON LAKE PROVINCIAL PARK  
SOIL LIMITATIONS FOR  
PLAYGROUND AREAS



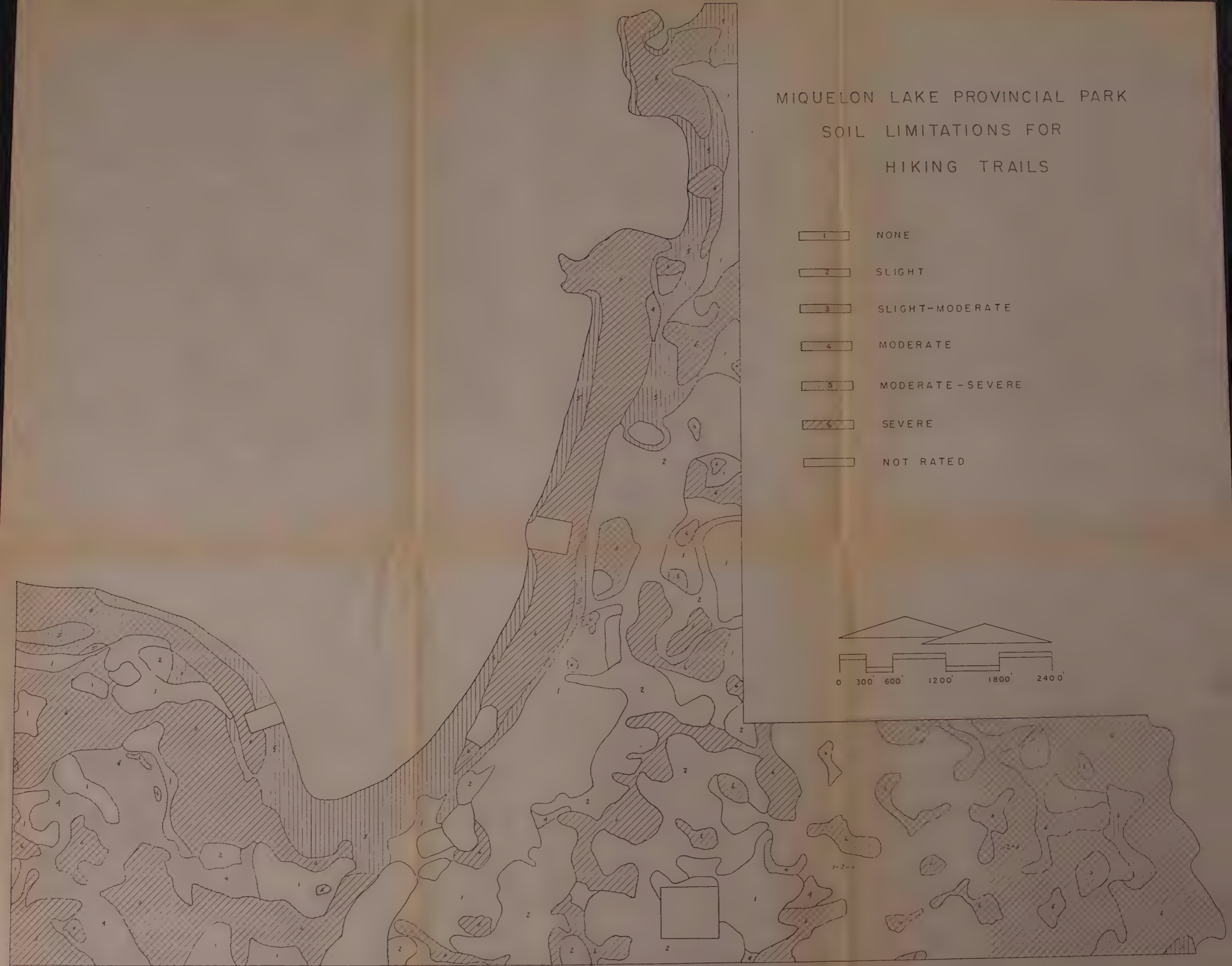
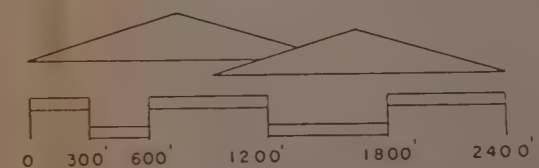
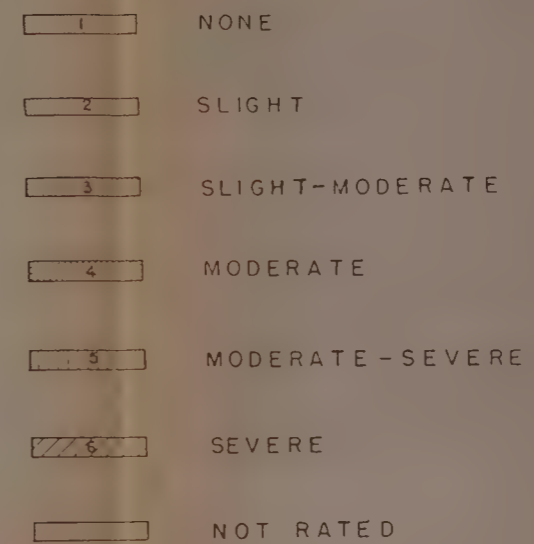


MIQUELON LAKE PROVINCIAL PARK  
SOIL LIMITATIONS FOR  
PICNIC AREAS



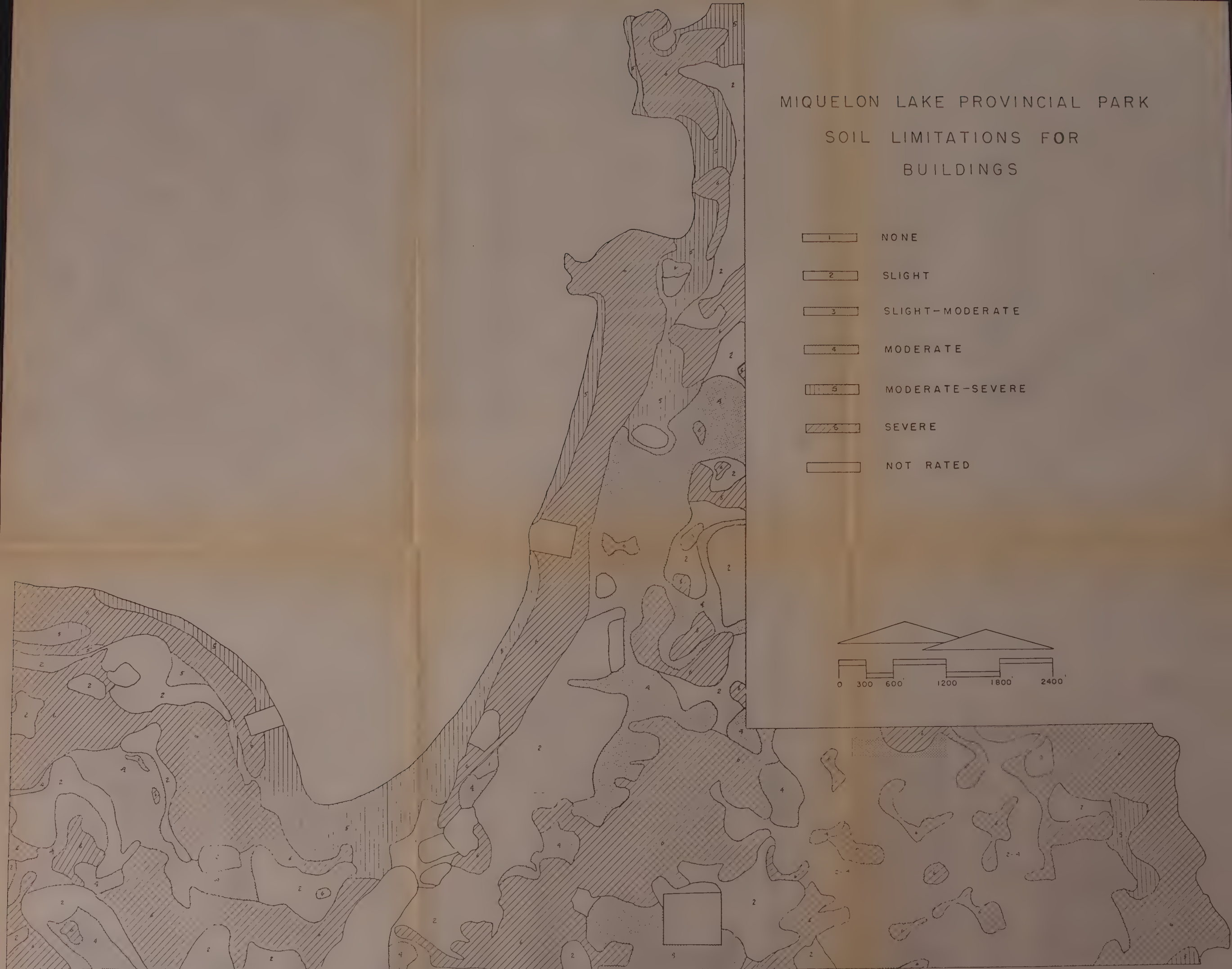
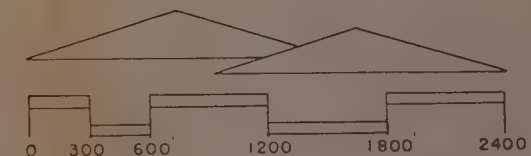
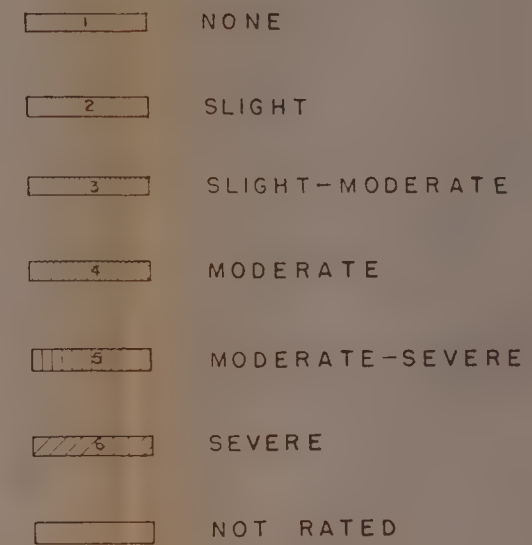


MIQUELON LAKE PROVINCIAL PARK  
SOIL LIMITATIONS FOR  
HIKING TRAILS



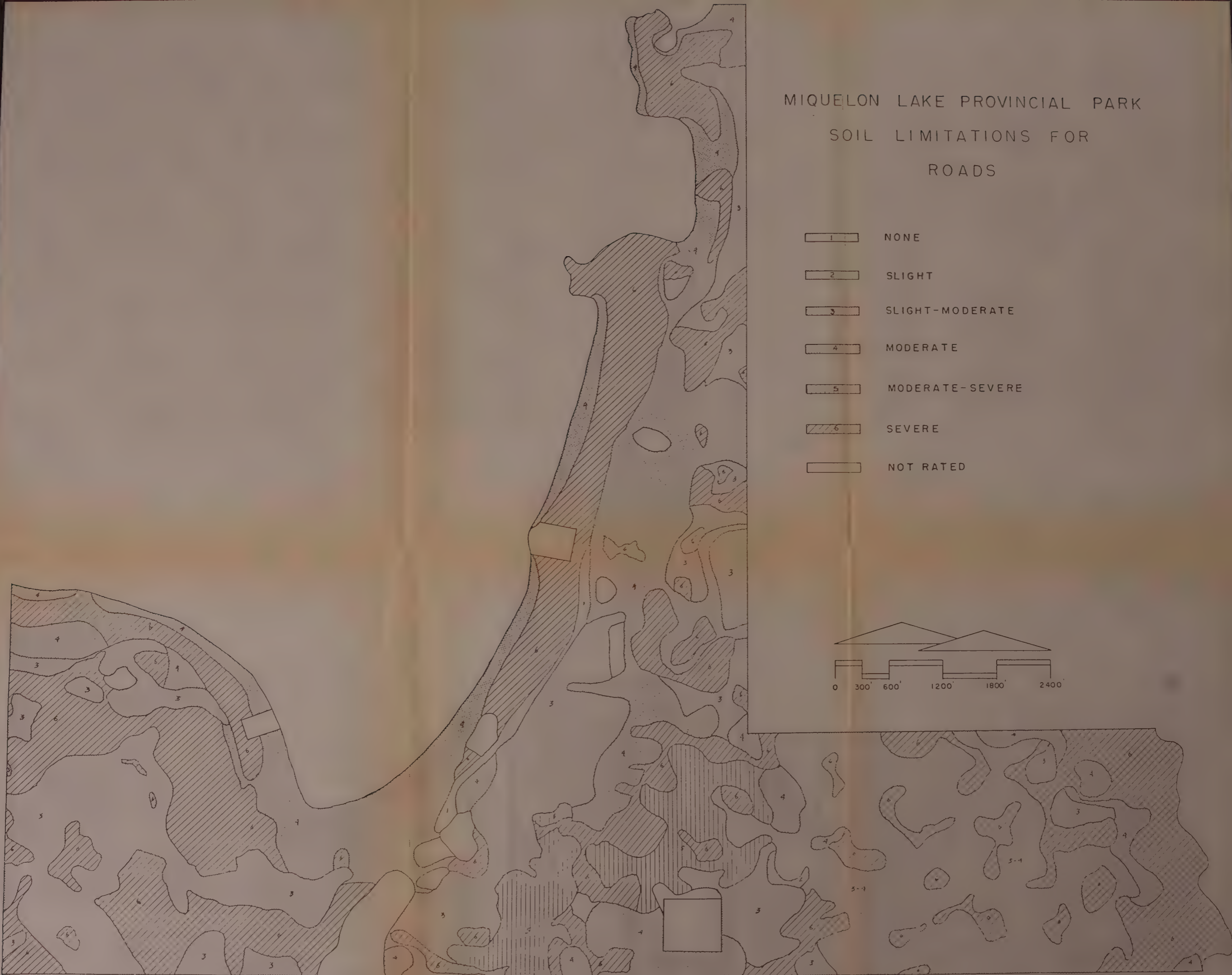
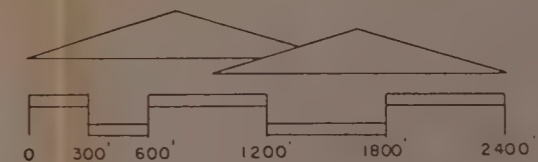
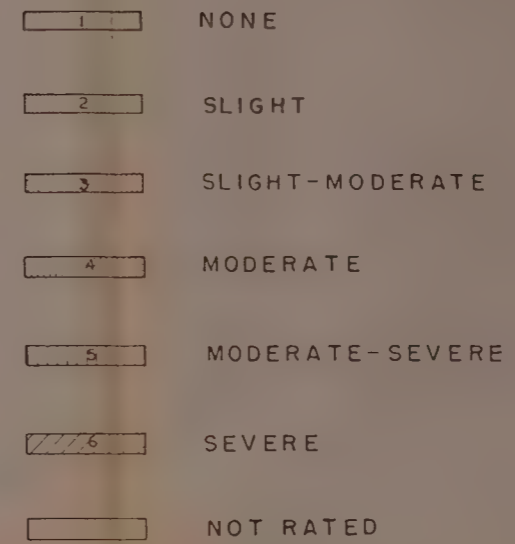


MIQUELON LAKE PROVINCIAL PARK  
SOIL LIMITATIONS FOR  
BUILDINGS



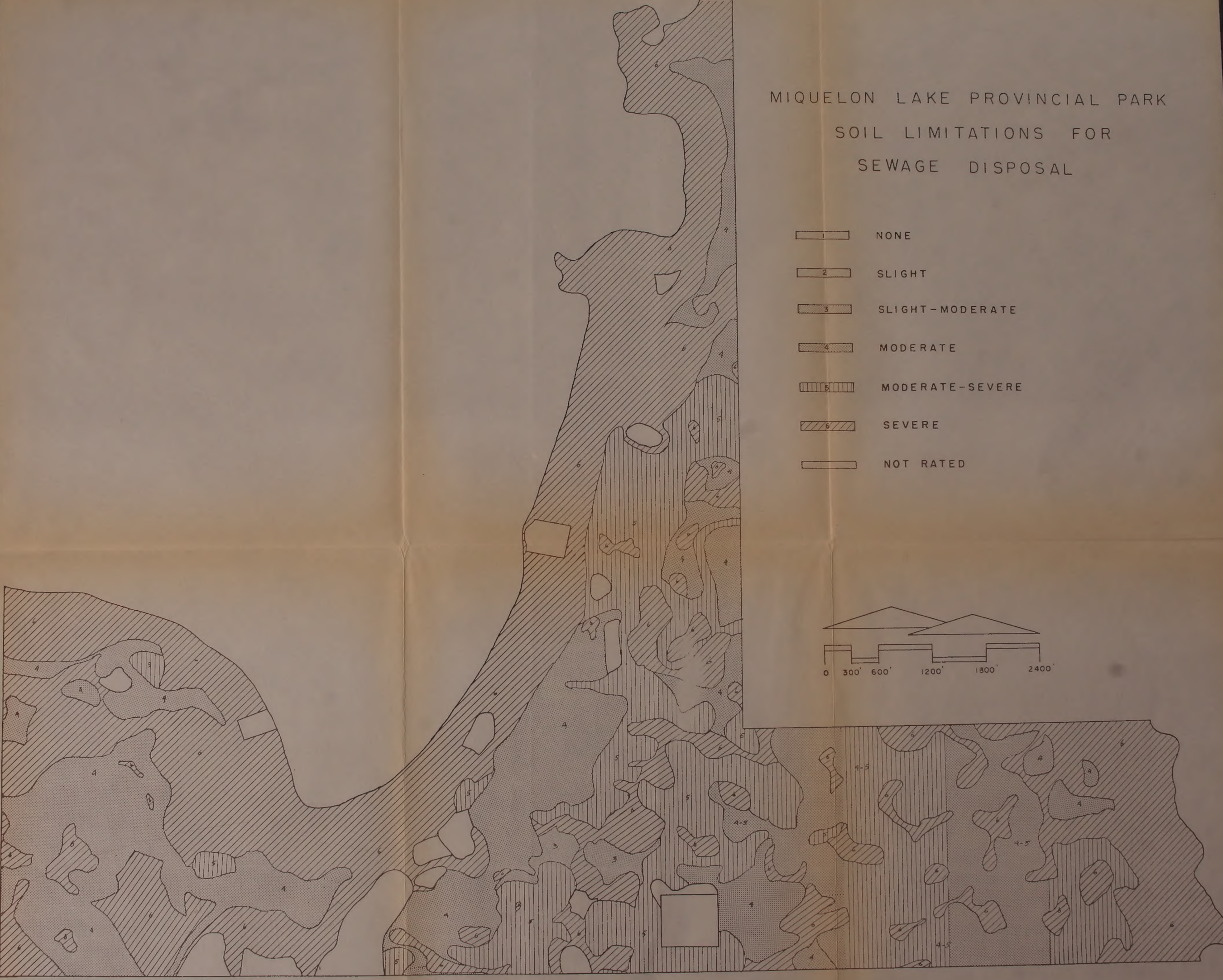
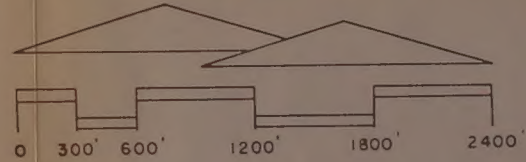
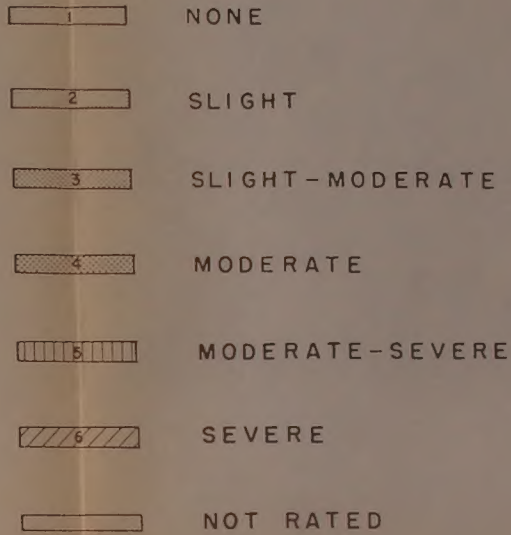


MIQUELON LAKE PROVINCIAL PARK  
SOIL LIMITATIONS FOR  
ROADS





MIQUELON LAKE PROVINCIAL PARK  
SOIL LIMITATIONS FOR  
SEWAGE DISPOSAL





SOILS MAP  
OF  
MIQUELON LAKE PROVINCIAL PARK

LEGEND

CHERNOZEM SOILS

- Falun (Fn) : Orthic Dark Gray Chernozem developed on till of Edmonton Formation origin.
- Egremont (En) : Gleyed Dark Gray Chernozem developed on till of Edmonton Formation origin.

MINIETIC SOILS

- Monique (Mq) : Gray Solod developed on fine textured lacustrine deposits overlying till at less than 90 cm.

LUVISOLIC SOILS

- Cooking Lake (Ck) : Orthic Gray Luvisol developed on till of Edmonton Formation origin.
- Uncas (Un) : Orthic Dark Gray Luvisol developed on till of Edmonton Formation origin.
- Maywood (Mw) : Orthic Gray Luvisol developed on fine textured lacustrine deposits.
- Tawayik (Tk) : Orthic Dark Gray Luvisol developed on fine textured lacustrine deposits overlying till at less than 90 cm.

REGOSOLIC SOILS

- Lindbrook (Lk) : Orthic Regosol developed on coarse textured outwash deposits on fine and medium gravel.
- Bittern Clay (BIC) : Orthic Regosol developed on fine textured material recently exposed by receding lake waters.

GLEYSOLIC SOILS

- Onoway (On) : Humic Gleysol developed on till.
- Mapova (Mp) : Humic Eluviated Gleysol developed on till.
- Demay (Dy) : Low Humic Eluviated Gleysol developed on till.
- Raven (Rv) : Humic Gleysol developed on fine textured lacustrine deposits.
- Deville (De) : Saline Orthic Gleysol developed on fine textured lacustrine deposits.
- Westwind (Ww) : Saline Low Humic Eluviated Gleysol developed on fine textured lacustrine deposits.
- Boag (Bo) : Saline Rego Gleysol developed on fine textured lacustrine deposits.
- Wanisan (Wi) : Saline Rego Gleysol developed on fine and medium beach sands overlying till or fine textured lacustrine deposits at less than 90 cm.
- U.G. : Undifferentiated Gleysol.

ORGANIC SOILS

- Mesic Humisols (M.H.) : Organic soils having On and Oh horizons greater than 30 cm. thick that consist of semi- and well-decomposed remains of coarse grasses, sedges, and reeds.

ALTERED AREAS

- Man Made Features (X) : Parking lots, filled areas, levelled areas, sewage disposal lagoons, etc.

FASE CLASSES

- Topography : I: 0 - 25 complex slopes.  
II: 2 - 51 complex slopes.  
III: 5 - 92 complex slopes.  
IV: 9 - 151 complex slopes.  
V: 15 - 301 complex slopes.  
VI: > 301 complex slopes.

- Stoniness : S1: Slightly stony land.  
S2: Moderately.  
S3: Very.  
S4: Exceedingly.  
S5: Excessively.

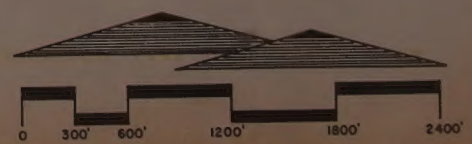
- Depth of Sand (W) : 2: 0 to 15 cm.  
3: 16 to 30 cm.  
4: 31 to 60 cm.  
5: > 60 cm.

- Peaty (P-) : Soils with between 15 and 30 cms. of undifferentiated organic surface deposits.

- Coarse (C.) : Soils containing more coarse fragments than is typical for the series.

OTHER SYMBOLS

- Sloughs.
- Underlain by bedrock.



**B29950**